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Ten-Year Development of Douglas-Fir and Associated Vegetation After Different Site Preparation on Coast Range Clearcuts

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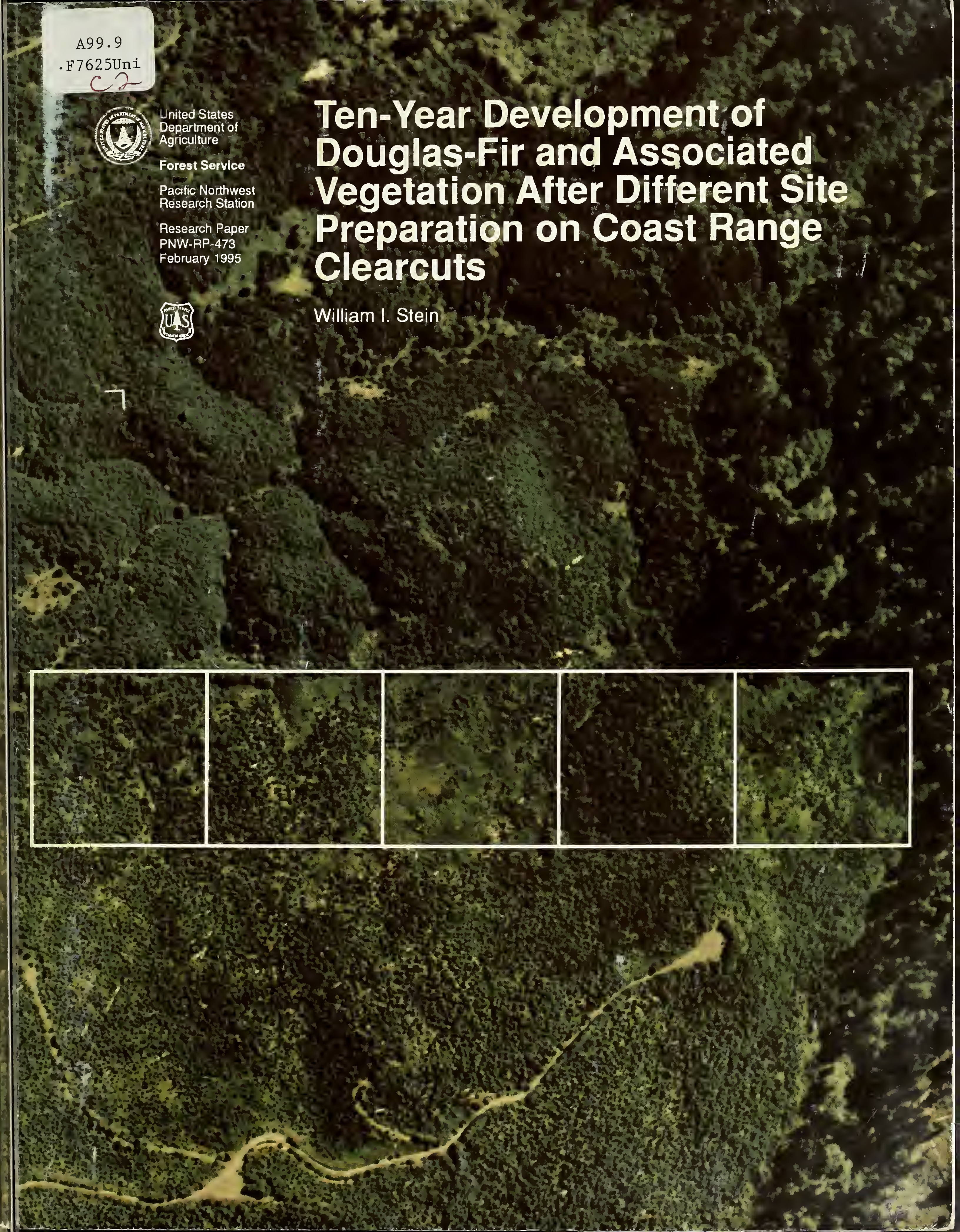

Cover Description

Aerial view of 9-year-old stands that developed after different site preparation—left to right, slash and burn, broadcast burn, no preparation, aerial spraying with glyphosate, manual spot-clearing.

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Abstract

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Side-by-side comparisons were made in an operational-sized, replicated experiment, installed in 1980-81 on four areas in the Coast Ranges of Oregon, to determine the effects of six methods of site preparation on the subsequent survival and growth of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and associated vegetation. A decade later, tree survival, total height, and stem caliper were significantly greater after site preparation by broadcast burning, slashing and burning, spraying Tordon 101 and burning, or aerial spraying of glyphosate than for manually spot-clearing vegetation at planting time, or no site preparation, and the differences were still increasing. Protecting seedlings from animals, primarily mountain beaver (*Aplodontia rufa*), with plastic mesh tubing resulted in 13 percent higher survival; and protected trees averaged 6 percent taller, 9 percent larger in stem diameter, and 49 percent more in volume than unprotected trees at 10 years. Protection improved seedling performance in every site-preparation treatment.

Site preparation by burning reduced total cover the most, from 50 to 5 percent or less. Vegetation recovery in all treatments was rapid; original levels were exceeded by midsummer 1981, the first posttreatment growing season. Total cover on spot-cleared areas almost equaled that on unprepared areas by 1982 but not until 1985 or later on burned or sprayed areas. Herbaceous vegetation was a much higher proportion of total cover for 5 years after burning or spraying than after spot-clearing or no site preparation, but eventually all areas were dominated by woody vegetation. Removal of the overstory by logging fostered diversity among dominant plant species and initiated successional trends in all areas. Site preparation caused large differences in the frequency of occurrence and surface area dominated by individual species but only minor increases in the total number of species. Dynamics of individual species or groups are shown by the frequency, cover, and average height of their dominance in each treatment over time.

Site preparation by burning or spraying and protection from foraging animals were required to obtain more than minimum tree stocking and growth, even in moist coastal conditions. The study results are most specific to the salmonberry (*Rubus spectabilis* Pursh) brush type but certainly have wider applicability throughout the Coast Ranges and beyond wherever a heavy cover of competing vegetation develops rapidly and populations of foraging mammals are high.

Keywords: Reforestation, Pacific Northwest, Coast Ranges, clearcutting, Douglas-fir, red alder, salmonberry, groundsels, site preparation, broadcast burning, slash and burn, spray and burn, manual spot-clearing, Tordon 101, glyphosate, planting, seedling protection, seedling survival, seedling growth, plastic mesh tubes, vegetation succession, species diversity, relative costs.

Summary

Key obstacles to reforestation in the Coast Ranges of Oregon may include large amounts of woody debris and residual live vegetation, rapid establishment of dense annual vegetation and fast regrowth of residual or invading woody vegetation, and heavy foraging by wildlife on newly planted tree seedlings. Several methods of site preparation can be used to improve site accessibility and reduce vegetative competition on clearcuts. Use of each method involves questions about biological effectiveness, cost, and environmental impacts. This cooperative endeavor, initiated in 1980-81 between the Siuslaw National Forest and the Pacific Northwest Research Station, addressed such questions in a side-by-side comparison of six site-preparation alternatives.

The decade-long study was conducted as a split-plot randomized blocks experiment on four areas, each with six 2-hectare (5-ac) plots, one for each site-preparation method. Mixed stands of conifers and hardwoods had been logged recently from the sites, and a substantial understory, primarily of salmonberry (*Rubus spectabilis* Pursh),[1] remained. With appropriate timing, these site-preparation methods were applied: aerial spraying with glyphosate,[2] broadcast burning, slashing live vegetation and later broadcast burning, aerial spraying with Tordon 101 and later broadcast burning, manual slashing of 1.2-meter (4-ft) radius spots, and no site preparation. After site preparation, 2-0 Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) seedlings were planted in winter or early spring 1980-81 on each 2-hectare (5-ac) plot; alternate seedlings were protected by plastic mesh tubing. Trees at designated points were measured for height and stem caliper immediately after planting and after growing seasons 1-5, 7, and 10. At the same designated points, vegetation was measured along a 240-centimeter (7.9-ft) linear transect before site preparation and thereafter on nearly the same schedule as for trees.

The study areas are located 5 to 27 kilometers (3 to 17 mi) inland from the Oregon Coast, are spread across more than 1 degree of latitude, and range in elevation from 76 to 396 meters (250 to 1,300 ft). Slopes on the areas range from 17 to 81 percent and represent north, east, and west aspects. Slash averaged 127 metric tons per hectare (57 short tons per ac) before broadcast burning and 67 metric tons per hectare (30 short tons per ac) afterward. Soil texture ranges from sandy loam to clay loam on the study areas. The soils generally are deep and well drained and have formed from sandstone and shale except for one area where the parent material is basalt.

The seedlings planted initially averaged 43 centimeters (17 in) tall and 5.2 millimeters (0.2 in) in stem caliper at 15 centimeters (6 in) aboveground. A decade later, survivors averaged 680 centimeters (22.3 ft) tall and 135 millimeters (5.3 in) in stem caliper. About 99 percent of surviving trees had achieved a breast high diameter (137 cm or 4.5 ft) that averaged 103 millimeters (4.1 in).

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[1] Scientific and common names of tree species are from Little 1979; names of other plants are from Hitchcock and Cronquist 1974; and names of animals are from Black 1992.

[2] The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

Survival averaged 72 percent—65 percent for unprotected trees, 78 percent for trees protected by plastic mesh tubing. Protected trees also averaged 6 percent taller and 9 percent larger in stem caliper. Nearly half of total losses occurred in the first 10 months after planting and close to another fifth in year 2. Thirty-seven percent of all mortality occurred among seedlings showing no visible damage. Over the decade, two damaging factors—stem clipping by animals and overtopping—each caused about one-fourth of total seedling mortality.

Tree survival, total height, and stem caliper were significantly greater 10 growing seasons after site preparation by broadcast burning, slashing and burning, spraying Tordon 101 and burning, or aerial spraying of glyphosphate than after manually spot-clearing vegetation at planting time or no site preparation. Survival averaged 55 percent without site preparation and 64 to 81 percent with site preparation. Total height averaged 592 centimeters (19.4 ft) on unprepared sites and 582 to 756 centimeters (19.1 to 24.8 ft) on prepared sites. Stem caliper averaged 112 millimeters (4.4 in) for spot-clear and no site preparation and 141 to 154 millimeters (5.6 to 6.1 in) for the other four site-preparation treatments. Statistically significant differences (P = 0.08 or less) among site-preparation treatments developed gradually; for stem caliper, they became evident the second year, for height and survival, the fourth year.

Broadcast burning plus tubing of seedlings yielded the highest volume (fig. 1) and dollar return relative to expenditures made above the base costs associated with no site preparation. Three other methods—slash and burn, spray and burn, and spraying alone—also showed large gains, but manually clearing a 1.2-meter (4-ft) radius around individual planting spots cost more relative to the yield produced than no site preparation at all. Tubing of seedlings increased volume yield in every treatment; the average gain was 49 percent, ranging from 32 percent in spray-and-burn site preparation to 75 percent with no site preparation. Size differences resulting from site preparation and seedling protection are evident in the crop-tree component of the stands; thus, the gains will carry forward for years. In fact, the differences between the four best treatments and the other two are still increasing.

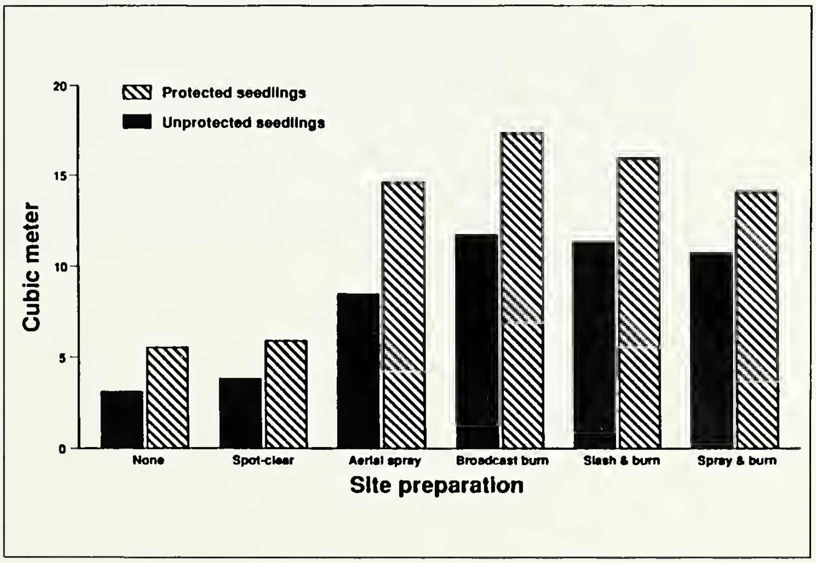

Figure 1—Volume per acre 10 years after each site preparation for unprotected and protected seedlings.

Live vegetation covered about half the ground surfaces at the start of the study in 1980, was reduced to 5 percent or less by broadcast burning, to 26 percent by spot-clearing, and little if any by spraying glyphosate. By midsummer of the first season after site preparation (1981), total cover in every site-preparation treatment was higher than it was originally—the recovery represented a 25-percent posttreatment gain on unprepared sites, 2 percent in sprayed areas, 41 percent in spot-cleared areas, and 54 to 58 percent in burned areas. Total cover on spot-cleared areas almost equaled that on unprepared areas by midsummer of the second season (1982), but not until the fifth season (1985) or later did cover on burned or sprayed areas fully equal that on unprepared sites. Woody vegetation comprised about two-thirds of the residual cover; but for 5 years after burning or spraying, herbaceous vegetation was a much higher percentage of the total cover than after spot-clearing or no site preparation.

Salmonberry cover was drastically reduced by every site-preparation treatment, especially by glyphosate spraying, and its recovery differed by treatment. Salmonberry peaked in the fifth growing season (1985) at about 50-percent cover in unprepared and spot-cleared areas and under 25 percent in the other treatments. Reductions in both height and density of salmonberry caused by burning or spraying provided the opportunity for other species, especially Douglas-fir, to expand and thrive. When salmonberry dominance peaked, Douglas-fir cover averaged about 25 percent in burn or spray treatments, less than half as much in unprepared and spot-cleared areas. Since then, the cover of Douglas-fir has more than doubled, cover of red alder (*Alnus rubra* Bong.) has markedly increased, and salmonberry dominance has correspondingly declined.

Removal of the overstory and subsequent site preparation triggered changes in species dominance throughout the decade. Due to site preparation, large differences developed in species frequency and cover, but only minor differences occurred in the total number and mix of species present. Species diversity first increased in every treatment and later decreased to near initial levels, with a shift to woody cover occurring first on unprepared and spot-cleared areas and several years later in other treatments. Only false azalea (*Menziesia ferruginea* Smith) clearly lost dominance because of burning; red alder and cascara buckthorn (*Rhamnus purshiana* DC) definitely benefited from disturbance provided by every treatment. Eight species or groups averaged 1-percent cover or more initially (1980), 5 just after site preparation, 14 in mid-decade, and 9 after a decade. The net effect of disturbance by site preparation was some increase in species diversity, and a much higher proportion of herbaceous species, which aided tree establishment and provided a more mixed habitat for animals and birds.

Even in moist coastal conditions, site preparation by burning or spraying and protection from foraging animals were required to obtain more than minimum tree stocking and growth. Harvesting, site preparation, and planting must be meshed to provide planted trees as much advantage as possible over the competing vegetation. Timing is a key factor in reforestation success whether site preparation is used or not. High-quality, large stock that can withstand the expected pressures from animals and competing vegetation should be used. Study results show that relatively short-term reductions and changes in vegetative cover obtained through site preparation are critical for improving plantation development. These findings are most specific to clearcuts in the salmonberry brush type but certainly have wider applicability throughout the Coast Ranges and beyond wherever a heavy cover of competing vegetation develops rapidly and populations of foraging animals are high.

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Introduction

Forest lands in the Coast Ranges of western North America are highly productive, and substantial efforts are made to achieve adequate reforestation promptly after harvest cutting. Key obstacles to reforestation may include (1) large amounts of woody debris and residual live vegetation, (2) rapid establishment of dense annual vegetation and fast regrowth of residual or invading woody vegetation, and (3) heavy foraging by wildlife on newly planted tree seedlings.

Several site-preparation practices, used singly or in combination, can be applied in the Coast Ranges to reduce vegetative competition and foster conifer establishment and growth. The most common combination used in 1980, when this study was started, included aerial application of an herbicide to kill residual vegetation on the site before broadcast burning. Reasonably large nursery stock was then planted and caged within plastic mesh tubing if seedlings needed protection from animals. Fast-growing, well-stocked young stands provided evidence that this combination of reforestation practices commonly produced good results, but later release from brush or hardwoods still seemed necessary. Furthermore, because of costs or environmental concerns, some observers questioned the need for spraying, or burning, or tubing, or suggested that other practices—manual brush cutting, for example—might produce equivalent or superior results. The duration and extent of site-preparation effects was also uncertain. The practices in use were based on limited research and much experience gained from short-term operational trials (Stewart 1978), but critical quantitative side-by-side comparisons of practices still were needed to determine relative biological effectiveness and costs and to develop better guidelines for managing fast-growing competing vegetation.

In this study, six of the most feasible site-preparation options were compared side-by-side in a replicated, operational-scale experiment. The four study sites represented some of the most difficult coastal reforestation conditions—where a tall, dense understory of salmonberry (*Rubus spectabilis* Pursh) was well established under an alder and scattered conifer overstory before the areas were harvested. This paper summarizes the information obtained by measuring the growth and development of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and associated vegetation periodically for a decade and provides insight on tree, vegetation, and wildlife interactions after different site preparation.

The study was a cooperative endeavor between the Siuslaw National Forest and the Pacific Northwest Research Station of the U.S. Department of Agriculture, Forest Service. Its impetus was a nationwide effort by the Forest Service to compare chemical and manual site-preparation methods in major forest types. Supplemental funding to assist the effort was provided by the Washington and Regional offices; the 10th-year examination was part of Coastal Oregon Productivity Enhancement efforts.

Reforestation Conditions

The Coast Ranges in Oregon and Washington constitute a maturely dissected, low-elevation to midelevation landscape supporting primarily conifer forests growing in a cool and wet maritime climate (Franklin and Dryness 1973, Snavely and others 1979). Elevations of main ridges in the largely moderate to steep terrain range from 450 to 750 meters (1,475 to 2,460 ft); scattered peaks extend above surrounding ridges to a maximum of 1249 meters (4,097 ft). The fertile soils are primarily Haplumbrepts (Western Brown Forest soils) of sandstone origin that have a wide range of characteristics. The coastal region has a long, mild growing season. Mean

maximum temperatures in July range from about 20 to 27 ^{o}C (68 to 80 ^{o}F) and mean minimum temperatures in January from slightly below 0 to 2.5 ^{o}C (30 to 37 ^{o}F). The mean annual precipitation ranges from 100 to 300 centimeters (40 to 120 in) with most occurring as rain during winter months. For some distance inland from the coast, characteristically infrequent precipitation in the summer is supplemented by condensation from coastal fogs (Isaac 1946).

Subclimax Douglas-fir stands predominate among the native conifer forests in the Coast Ranges. Most of these forests are relatively young, 150 years or less, and successional progression to Sitka spruce (*Picea sitchensis* (Bong.) Carr.) climax near the coast or western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and western redcedar (*Thuja plicata* Donn ex D. Don) climax farther inland is mostly in early stages. Reforestation efforts center on the reestablishment of Douglas-fir, sometimes in mixture with western hemlock or western redcedar. Although Sitka spruce regenerates vigorously, it is not often planted because its development as a healthy component of young stands is thwarted by attacks of the white pine weevil (*Pissodes strobi* Peck). Because of the terrain and type of forest, clearcutting has been the primary method of harvest, and logs are removed primarily by cable methods.

Stands of red alder (*Alnus rubra* Bong.) and mixtures of red alder and conifers also are common in the Coast Ranges. Reforestation objectives after such stands are harvested usually include establishment of conifers. Preharvest development of competing brush is often highest in hardwood or hardwood-conifer stands and so is the consequent difficulty of establishing regeneration (fig. 2).

Figure 2—Salmonberry (*Rubus spectabilis* Pursh) and other species often comprise a formidable preharvest understory in mixed stands of hardwoods and conifers.

Hardwood, shrub, and fern species, found as scattered individuals to thick concentrations in the original stands, often develop vigorously after clearcutting. Resprouting species of widespread occurrence include bigleaf maple (*Acer macrophyllum* Pursh), vine maple (*Acer circinatum* Pursh), red alder, salmonberry, thimbleberry (*Rubus parviflorus* Nutt.), trailing blackberry (*Rubus ursinus* Cham. & Schlecht.), salal (*Gaultheria shallon* Pursh), Oregongrape (*Berberis* spp. L.), sword-fern (*Polystichum munitum* (Kaulf.) Presl), bracken-fern (*Pteridium aquilinum* (L.) Kuhn.), and huckleberries (*Vaccinium* spp. L.). Invading woody pioneers include

bitter cherry (*Prunus emarginata* Dougl. ex Eaton), elder (*Sambucus* spp. L.), and cascara buckthorn (*Rhamnus purshiana* DC.). Fast-growing herbaceous species that rapidly invade disturbed areas include common groundsel (*Senecio vulgaris* L.), tansy ragwort (*Senecio jacobaea* L.), fireweed (*Epilobium angustifolium* L.), burnweed (*Erechtites arguta* DC.), foxglove (*Digitalis purpurea* L.), pearly-everlasting (*Anaphalis margaritacea* (L.) B. & H.), candy flower (*Montia* spp. L.), and grasses (*Gramineae* spp.). A dense, tall, herbaceous cover often develops in the first season; woody species become dominant as the annuals diminish in subsequent seasons.

Coast Range forests support many kinds of wildlife; some species are attracted to cleared areas and feed on conifers and the associated vegetation. Use of reforestation areas by Roosevelt elk (*Cervus elaphus roosevelti*), black-tailed deer (*Odocoileus hemionus columbianus*), rabbits (*Sylvilagus* spp.), and mountain beaver (*Aplodontia rufa*) is nearly ubiquitous, but the intensity of use varies by area, year, and season. Mountain beaver, primitive, nocturnal rodents (Hooven 1977), can be especially damaging because they clip the stems of young tree seedlings near ground line, burrow among the roots, chew the bark, or cut the branches of larger seedlings and saplings. Some damage from animals can be expected in all plantations; severe damage is less certain and less predictable. Conversely, animals also forage on competing vegetation, thereby reducing its retarding effect on tree seedlings.

The density and composition of the stands harvested, as well as the yarding method and level of wood utilization, have a great influence on postharvest site conditions and the reforestation practices needed. When dense conifer stands are cleanly removed, the slash and soil surface may be disturbed enough so that hand planting can be done successfully with no site preparation or with only broadcast burning of the slash. But, if the harvested stand was a mix of limby conifers and aging hardwoods with a well-developed understory of woody shrubs, more intensive site preparation often is required. Reduction of residual vegetation as well as slash becomes an important consideration.

For many years, broadcast burning has been the chief site-preparation method used in coastal forests. Aerial spraying of herbicides to reduce residual vegetation, or to desiccate it before burning, were options used in brushy areas. In 1980, the use of either broadcast burning or aerial spraying was increasingly being questioned. Were these site-preparation methods truly effective, ecologically sound, and necessary to ensure adequate planting and growth of conifers? Side-by-side comparison of methods was needed to provide definitive answers.

Methods

Six site-preparation methods were compared side by side on four freshly harvested areas located on the Siuslaw National Forest in the Coast Ranges of Oregon. The areas were chosen to represent difficult reforestation conditions—where a heavy understory of salmonberry had developed under an alder and scattered conifer overstory before the stand was removed. Mountain beaver inhabited all four areas, and use by deer, elk, and rabbits also was anticipated.

Answers were sought for these four questions:

- Does method of site preparation influence subsequent survival of large 2-0 Douglas-fir nursery stock?

- Does method of site preparation affect subsequent height and diameter growth of the planted Douglas-firs?
- Does protection by tubing improve the survival, height, or diameter growth of the Douglas-firs; does the effect vary on differently prepared sites?
- Does percentage of cover, height, or composition of competing vegetation differ initially or after site preparation?

Study Design and Techniques

The study was a split-plot randomized blocks experiment having four replications (areas) and six site-preparation treatments on each area. Two hectares (5 ac) were judged the minimum size for which operational treatments, particularly aerial spraying, were reasonably feasible and representative.

Six 2-hectare (5-ac) plots were fitted onto each area to best include broadly representative site conditions. On two areas (LBJ and Camp 76), the plots were located adjacent to each other in a single tier across the slope; in the other two, plots were more clustered. Twenty-two of the 24 plots were square, the other two were oblong.

Tree and vegetation development were measured at designated points along four or six equal-length lines spaced equidistantly within each plot. The lines were located within a wide buffer (fig. 3) and contained 20 or 30 equally spaced points. Points were 2.4 to 3 meters (8 to 10 ft) apart to coincide with intended spacing of trees. Each point within a line served as the center for a 240-centimeter (7.9-ft) vegetation transect located perpendicular to the cross-contour direction of the sample line.

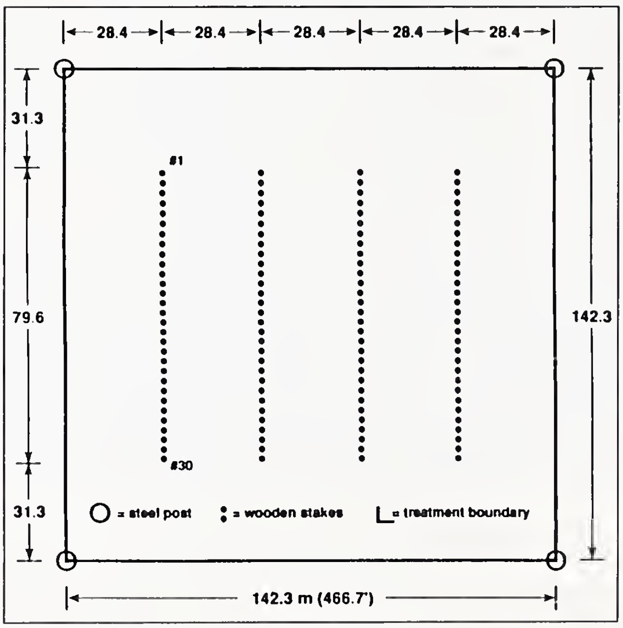

Figure 3—Layout of a typical square 2-hectare (5-ac) plot with 2.7- by 2.7-meter (9- by 9-ft) spacing of trees and accompanying vegetation transects.

Increments of the transect line intercepted by the uppermost layer of vegetation and by bare surfaces were tallied to the nearest centimeter (0.4 in), with 5 centimeters (2.0 in) being the minimum length separately recorded. However variable its actual height, only the top layer of vegetation intercepted by the transect line was tallied. Most woody species in the uppermost layer were tallied individually; the herbaceous species were more often tallied as genus groupings. The height of the main upper crown was measured in centimeters on the most prominent plant of up to three species found along each transect line.

After site preparation, each 2-hectare (5-ac) plot was planted with 2-0 Douglas-fir seedlings at the spacing specified for the site. A special effort was made to have a tree planted as near as possible to each prestaked point. Immediately after planting, trees in the sample lines were measured for total height in centimeters and stem diameter in millimeters at 15 centimeters (6 in) above mean ground level. After measurement, alternate trees were protected with 8- by 75-centimeter (3- by 30-in) plastic mesh tubing for protection from animals. Seedling size, weight, and morphology were determined from a sample of the nursery stock used on each study area.

Trees were remeasured for height and diameter (at 15 cm) after growing seasons 1-5, 7, and 10. A midseason observation was made during the first growing season to determine if the stock planted was alive and vigorous. At the 10th-year remeasurement, trees also were tagged and measured for diameter at breast height (d.b.h.)—at 137 centimeters or 4.5 feet aboveground. Tree condition and signs of animal damage were observed and systematically recorded at each examination. Vegetation transects also were measured on a periodic schedule starting with the initial measurement early in the growing season (May 15 to June 26, 1980) before site preparation, an examination soon after site preparation for those plots where treatment radically changed the cover, and then repeat examinations for all treatments about midsummer of the same years (except 1984) as tree heights were measured at the end of the growing season.

Descriptive information was obtained about each study area from available records and by specific sampling. Data on live vegetation present after harvest were produced by the first reading of vegetation transects. Slash level was estimated for each 2-hectare (5-ac) plot by using visual-estimation techniques in conjunction with photo series developed by Maxwell and Ward (1976). Such estimates were repeated for those plots where site preparation materially reduced slash. Soil texture and bulk density were determined for the main slopes on each study site by using the bead-cone technique to measure soil volumes removed (Flint 1983) and the hydrometer method for texture analysis (Day 1965). Azimuth and slope were determined with a hand compass and a relascope at one end of each sample line. Vegetation development was photographed periodically at designated observation points.

Tree survival, total height, and stem diameter data were summed to provide means, standard errors, and minimum and maximum values by areas, treatments, protection levels, and examination dates. The basic sample for which a mean was calculated comprised all unprotected or all protected trees observed on a plot.

Tree data were subjected to variance analysis for a split-plot, randomized blocks design with site preparation as the whole-plot factor and tree protection as the subplot factor. Initial seedling height and caliper were used as covariates in a separate set of analyses but did not yield statistically different results. Likewise, survival data were subjected to an arc sine-square root transformation with little difference in results, particularly as trees became older. Thus, all significant differences presented are founded on variance analyses of nontransformed data. Probability values as determined by *F*-test are included where appropriate. Duncan's Multiple Range test (Duncan 1955) was used to identify significant differences among ranked means at the 1 and 5 percent probability levels. Orthogonal contrast tests were also made for selected groupings of site-preparation treatments.

Stem volume for the average tree produced in 10 years after each method of site preparation was calculated as a conical form with the average diameter at 15 centimeters (6 in) aboveground as the width of the base and the average total height as the length of the cone. Volume per acre (metric) was determined by multiplying the average volume per tree by the number of surviving trees per acre, obtained by reducing a defined full stocking of 400 trees per acre by the survival percentage resulting from each method of site preparation.

Vegetation transect data were summarized by frequency and cover for individual species or species groups. Tabular and graphical techniques were used to demonstrate the effect of site preparation and time on vegetation development, changes in species composition, and in height of individual species. Species were included in condensed tables based on a criterion of 1-percent or more cover (average for the four areas) at that examination.

Area Descriptions

The study areas, each 20 hectares (50 ac) or larger, are located 5 to 27 kilometers (3 to 17 mi) inland from the Oregon Coast in the geographic territory bounded by longitude 123°45' to 124°00' W. and latitude 44°11' to 45°29' N. (table 1). All four

Table 1—Description of the study areas

Characteristic	Formader	LBJ	Camp 76	Farmer E	Farmer F
Location:					
Longitude (°W)	123°59'	124°00'	123°45'	123°55'	123°51'
Latitude (°N)	44°11'	44°29'	44°17'	45°13'	45°18'
Distance inland (miles)	6	4	17	3	5
Forest	Siuslaw	Siuslaw	Siuslaw	Siuslaw	Siuslaw
District	Waldport	Waldport	Alsea	Hebo	Hebo
Township	T. 16 S.	T. 12 S.	T. 15 S.	T. 4 S.	T. 3 S.
Range	R. 11 W.	R. 11 W.	R. 9 W.	R. 10 W.	R. 10 W.
Section	14, 15	35	2, 3	16	24
Site:					
Size (acres)	102	142	63	50	71
Elevation (feet)	950-1300	250-650	350-1000	600-800	600-800
Aspect (degrees)	West 271	West 257	North 3	East 101	Southeast 142
Slope (percent)—					
Average	16.7	31.4	58.7	81.3	28.5
Range	4-32	15-50	35-88	80-82	15-46
Soil texture	Loam	Sandy loam	Loam	Loam	Loam
Vegetation type	Alder-salmonberry	Alder-salmonberry	Alder-salmonberry	Alder-salmonberry	Alder-salmonberry-vine maple
Slash (short tons)	59	73	54	38	31
Big-game evidence	Heavy	Light	Light to moderate	Heavy	Light

A. Formader

B. LBJ

C. Camp 76

D. Farmer

Figure 4—Postharvest appearance of the study areas before site preparation.

are located on the Siuslaw National Forest at elevations ranging from 76 to 396 meters (250 to 1,300 ft). Average slopes on the areas range from 17 to 81 percent, and dominant aspects represented include north, west, and east. All have minor ridges and draws providing short slopes of other aspects (fig. 4).

Live vegetation present before site preparation covered 52 percent of study areas, ranging from 34 to 60 percent (table 2). The least cover was on Camp 76, the steepest area. On the average, about two-thirds of the dominant cover was comprised of woody shrubs and one-third of herbaceous species. Eight species were present in quantities averaging more than 1 percent of the dominant cover for the four areas—vine maple, salal, grass, candy flower, sword-fern, bracken-fern, thimbleberry, and salmonberry. These species were present on all four areas except salal, which was totally absent on Camp 76 plots, even though present and common there outside of plot boundaries. In both frequency of occurrence on transects (57.8 percent) and cover (22.4 percent), salmonberry was by far the most common species.

Table 2—Amount and composition of residual vegetation dominant on the study areas in 1980 before site preparation

	Study area									
	Formader		LBJ		Camp 76		Farmer		All	
Vegetation category	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
					Percent					
Total vegetation:		59.8		59.1		33.9		54.7		51.9
Woody		39.1		47.4		16.9		32.5		34.0
Herbaceous		20.7		11.7		17.0		22.2		17.9
Bare surface		40.3		40.9		66.1		45.2		48.1
Species averaging 1-percent cover or more:										
Acer circinatum	28.5	13.5	1.7	.3	7.1	1.9	13.8	5.4	12.7	5.3
Gaultheria shallon	2.2	.4	34.3	7.1			.4	+[a]	9.2	1.9
Gramineae spp.	8.2	1.8	.8	.1	4.2	.6	7.1	1.5	5.1	1.0
Herbaceous, misc.	11.0	2.3	3.8	.5	17.5	2.7	18.2	4.1	12.6	2.4
Montia spp.	48.2	11.4	14.9	4.3	18.1	2.6	35.8	5.9	29.2	6.1
Polystichum munitum	18.5	3.2	19.3	3.2	46.3	9.5	37.4	8.7	30.3	6.1
Pteridium aquilinum	5.6	1.1	9.0	2.7	2.4	.3	4.0	.8	5.2	1.2
Rubus parviflorus	.1	+	2.6	.4	1.0	.2	11.9	3.4	3.9	1.0
Rubus spectabilis	64.6	22.9	76.9	35.7	35.3	10.2	54.4	20.9	57.8	22.4
Total of 9		56.6		54.3		28.0		50.7		47.4

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Slash on the study areas averaged 124 metric tons per hectare (55 short tons per ac) and ranged from 70 to 163 metric tons per hectare (31 to 73 short tons per ac) (table 1). The least amount of slash was present on Farmer and the most on LBJ. In all areas, slash was far from uniformly distributed. Material 51 centimeters (20 in) in diameter or more usually comprised less than half the total.

About 10 soil series are represented on the study areas according to the recently developed soil survey maps for the Siuslaw National Forest (USDA Soil Conservation Service 1990). Soils in these series have in common that they are moderately deep to deep and generally well drained (table 3). Except for Formader, the soils have formed from colluvium or residuum from underlying sandstone and shale; basalt was the parent material for soils at Formader.

Loam was the average texture for specific samples taken from the top 30 centimeters (12 in) in each study area, but texture of individual samples ranged from sandy loam to clay loam (table 3). Bulk density of these friable coastal soils is relatively low and differed by location. The densities were somewhat higher for the steeper soils, those at Camp 76 and Farmer E. Soil particles greater than 4.75 millimeters in diameter constituted only 0.6 to 12.3 percent of the total particles per sample.

Site Preparation

Six site-preparation methods were compared side-by-side on each study area. These included the following:

Table 3—Soil characteristics on the study areas

Characteristic	Study area: Formader	LBJ	Camp 76	Farmer E	Farmer F
General:					
Soil series	Hembre/Klickitat	Winema Tolovana/Reedsport	Preacher/Bohannon Orford	Neotsu	Salander
Taxonomy	Andic Haplumbrepts Typic Haplumbrepts	Typic Dystrandepts Alic Fluvudands Typic Humitropepts	Typic Palehumults Andic Haplumbrepts	Alic Fulvudands	Typic Dystrandepts
Parent material	Basalt	Sandstone and shale Colluvium	Sandstone Arkosic sandstone Sed. and volcanic	Colluvium	Colluvium
Soil texture	Silt loam Gravelly clay loam	Silt loam Gravelly loam	Clay loam Gravelly loam Gravelly silt loam	Silt loam	Silt loam
Water-holding capacity	Deep, well-drained	Deep, well-drained	Deep, well-drained	Mod. deep, well-drained	Deep, well-drained
Site specific:					
Samples (number)	6	6	6	3	6
Texture—					
Average	Loam	Loam	Loam	Loam	Loam
Range—	Sandy loam-silt loam	Loam-sandy clay loam	Loam-clay loam	Loam	Loam-sandy loam
Sand (percent)	23-54	47-57	27-38	43-48	39-66
Silt (percent)	35-55	22-38	33-46	40-42	23-48
Clay (percent)	12-24	15-25	21-35	10-17	11-19
Bulk density:					
Samples (number)	6	6	6	3	5
Average (gram/centimeter^3)	0.55	0.67	0.78	0.86	0.60
Range	.47-.61	.58-.78	.71-.86	.69-.95	.44-.75
Size fractions (percent)—					
<2 mm	96.18	80.91	94.25	75.88	89.08
2-4.75	3.24	6.76	2.96	16.43	2.53
>4.75	.58	12.33	2.78	7.69	8.40

- No site preparation. The 2-hectare (5-ac) plot was planted without reducing or rearranging slash and residual vegetation except for the scalping required to plant the trees.
- Spot-clearing. Near planting time in 1981, live woody vegetation was cut to 15-centimeter (6-in) height or less for a 1.2-meter (4-ft) radius around each planted tree.
- Aerial spraying. Glyphosate (N-(phosphonomethyl) glycine) was sprayed in early fall 1980 at the rate of 2.52 kilograms per hectare (2.25 lbs per ac) acid equivalent in water applied at the rate of 94 liters of mix per hectare (10 gallons per ac). (Registration for forest site preparation: EPA 524-308-AA; SLN-OR-770055; trade name—Roundup(R)(Monsanto)).
- Broadcast burning. Slash was burned in summer 1980 after it had dried naturally during spring and early summer.
- Slashing and burning. Live woody vegetation was slashed in June 1980, allowed to dry along with logging slash, and then both were broadcast burned in summer 1980.

- Spraying and burning. Vegetation was aerially sprayed in May or June 1980 with a mix of picloram (4-amino-3,5,6-trichloropicolinic acid) and 2,4-D ((2,4-dichlorophenoxy) acetic acid) at the rate of 1.49 + 5.97 kilograms per hectare (1.33 + 5.33 lbs per ac) acid equivalent in water applied at the rate of 187 liters of mix per hectare (20 gallons per ac), and the plots were broadcast burned later in the summer. (Registration for forest site preparation: EPA 464-306; trade name—Tordon 101(R)(Dow)).

Site-preparation treatments were assigned as randomly as possible on each study area. Of necessity, however, plots to be burned had to be geographically located so that those to be left unburned could be successfully protected during burning of slash. The practical result was that the three plots to be burned and the three to be left unburned were identified first and then the treatments within each group were randomized among the three. Despite valiant efforts, the plots reserved from burning on Farmer F were not protected successfully, thus necessitating reestablishment of the unburned plots on another area (Farmer E) of the same timber sale. The two Farmer areas have similar elevations, aspects, and other characteristics, as shown in tables 1 and 3. From this point forward, study results from Farmer E and F will be reported and discussed as from a single study area.

Aerial spraying of Tordon 101, the first site-preparation treatment applied, was completed on designated plots in May or June of 1980, 1 to 5 months after timber harvest was completed (table 4). Spraying was done by helicopter and timed with new leaf development on salmonberry (fig. 5). The helicopter flew at speeds less than 97 kilometers per hour (60 mi per hr) and, wherever possible, at heights of 21 meters (70 ft) or less above the vegetative cover. D-45 nozzles were used on a boom spray system with an operating pressure between 1.7 and 2.4 bars. Spraying preceded burning by 54 to 102 days.

Table 4—Dates when specified reforestation activities were applied on each study area

Event	Formader	LBJ	Camp 76	Farmer E	Farmer F
Logging completed	12-79	3-80	2-80	5-80	6-80
Site preparation:					
Preburn slashing	6-10-80	6-10-80	6-26-80		6-80
Preburn spraying, Tordon 101	5-18-80	6-4-80	6-30-80		6-17-80
Broadcast burning	8-24-80	9-14-80	9-4-80		8-10-80
Spraying, glyphosate	9-26-80	9-25-80	10-3-80	9-24-80	
Spot-clearing	3-17-81	4-7-81	4/3-8/81	5-81	
Planting Douglas-fir:					
Spacing	10 x 10'	10 x 10'	9 x 9'	8 x 8'	8 x 8'
Date	3-16-81	4-7-81	3-23-81	12-31-80	12-30-80
Conditions	Sunny, cool	Overcast, cool	Overcast, rain	Overcast, rain	Overcast, rain

Preburn slashing was accomplished on designated plots in June 1980. The purpose of manual slashing was to kill and desiccate live vegetation and, thus, facilitate a cleaner, more uniform broadcast burn. All residual trees and large shrubs, such as vine maple, bigleaf maple, alder, and cascara buckthorn were cut within 1 meter (3 ft) of the ground with power saws (fig. 6). Strips or spots were cut in low brush to facilitate burning. The slashing preceded burning by 60 days or more, except perhaps on Farmer (table 4).

Figure 5—Appearance of young salmonberry tips and leaves 5 weeks after application of Tordon 101. Preburn spraying on each area was timed with stage of new leaf development.

Figure 6—Preburn slashing to desiccate live vegetation involved cutting all residual trees and large shrubs within 1 meter (3 ft) of the ground and cutting strips or spots in low contiguous vegetation.

Broadcast burning of slash was accomplished on designated plots between early August and mid-September. Plots were burned at each study site in conjunction with burning of adjacent clearcut area not within study boundaries. Timing of burns depended on fuel dryness, smoke-management restrictions, and other factors.

Slash present on plots before treatment varied substantially, ranging from 60 to 199 metric tons per hectare (27 to 89 short tons per ac) (table 5). Yet, averages were reasonably similar among site-preparation treatments, from 112 to 138 metric tons per hectare (50 to 62 short tons per ac). Slash on plots to be burned averaged 127 metric tons per hectare (57 short tons per ac) before burning and 67 metric tons (30 short tons per ac) after burning (fig. 7). Burning reduced slash by about 75 percent on Formader plots but only about 30 percent on LBJ plots. The burn and slash-and-burn plots at LBJ still had draws and islands with green vegetation and unburned slash.

Table 5—Slash tonnage in all site-preparation plots

Site preparation	Formader	LBJ	Camp 76	Farmer	Average
	Study area				
	Short tons per acre				
None	40.1	77.9	66.4	34.5	54.7
Spot-clear	54.6	49.3	54.2	42.1	50.1
Spray	61.0	88.9	38.0	38.7	56.7
Burn:					
Preburn	45.0	84.4	88.5	28.7	61.7
Postburn	12.5	67.9	30.9	—	37.1
Slash and burn:					
Preburn	78.3	83.1	36.9	26.9	56.3
Postburn	19.2	40.7	21.0	—	27.0
Spray and burn:					
Preburn	76.8	53.3	41.8	37.7	52.4
Postburn	15.4	44.5	16.4	—	25.4
Average:					
All plots	59.3	72.8	54.3	34.8	55.3
Preburn, 3 plots	66.7	73.6	55.7	31.1	56.8
Postburn, 3 plots	15.7	51.0	22.8	—	29.8

— = Data missing.

Glyphosate was aerially sprayed by helicopter between September 24 and October 3, 1980. The herbicide was applied in two flights, one at right angles to the other at speeds less than 97 kilometers per hour (60 miles per hr) and, wherever possible, at heights of 21 meters (70 ft) or less above the vegetative cover. A boom spray distribution system was used with disc-type teejet nozzles, D-8 orifice tips, no spinners, and an operating pressure between 1.7 and 2.4 bars. Leaves of brush species were fully developed for the season, and their abscission was nearing.

Clearing live vegetation from around planted trees was done at planting time or soon afterwards. The spot-clear treatment was applied differently at every study area (fig. 8). At LBJ, the contractor chose to cut existing brush, primarily salmonberry, with chain saws before the plot was planted. The clearing was so generous that practically all brush on the area was cut. At Formader, the contractor chose to cut swaths and move both cut brush and pole-size slash aside, thereby producing a windrow effect. At Camp 76, trees were planted first, and spot-clearing was done several days later. At Farmer, spot-clearing was done in early June, about 5 months after planting. On all spot-clear plots, clearing a 1.2-meter (4-ft) radius around the tree was achieved; on two areas, the clearing greatly exceeded the contract specification which required clearing about 50 percent of the surface. Timing of the treatment was later than desirable at Farmer since, by June, the 1981 growth of brush was well underway.

Formader

LBJ

A. Before broadcast burning

B. After broadcast burning

Figure 7—Broadcast burning reduced slash on most but not all surfaces of designated plots. On the average, burning reduced slash by 52 percent and the cover of residual live vegetation to 5 percent or less.

Application of site-preparation treatments was the responsibility of individual Ranger Districts on the Siuslaw National Forest. The Districts collaborated on a Forest-wide spraying contract so that the same contractor and pilot applied Tordon spray on all four study areas. Likewise, one contractor and pilot later applied glyphosate on all four areas. Manual slashing of residual trees and brush was accomplished independently on each District by use of their own crew or a contractor. Likewise, burning of slash, spot-clearing, and planting were the responsibility of each District. The Forest-wide spray contract as well as the efforts directed by individual Districts represented operational methods in use at the time.

Figure 8—Clearing live brush from a 1.2-meter (4-ft) radius around newly planted trees was accomplished differently at each study area. (A) Live brush and slash were windrowed before planting at Formader. (B) Virtually all brush was cut before planting at LBJ. (C) Spots were cleared after trees were planted at Camp 76 and Farmer.

By planting time, vegetation development was at markedly different stages depending on the site-preparation treatment. For the study areas, where stand removal was completed before or early in the 1980 growing season, residual and colonizing vegetation had up to a full season to develop on plots given no site preparation. That same vegetation development was present when four plots were spot-cleared in early 1981. Burning in late summer 1980 substantially reduced live vegetation, but in the mild coastal climate, noticeable greening up from resprouts and grass occurred. Salmonberry sprouts were common on LBJ 3 weeks after the mid-September burn. After fall spraying, dominant vegetation faded gradually the next spring, but often an existing understory was released.

Planting

All four study areas were planted with Douglas-fir stock in either winter or spring 1980-81 (table 4). Two-year-old stock was used throughout, but each area was planted with stock of an appropriate size and local seed source. Tree spacing ranged from 2.4 by 2.4 to 3 by 3 meters (8 by 8 to 10 by 10 ft), as specified in the reforestation plan for each area. A mix of two species was planted at Camp 76—two-thirds Douglas-fir and one-third western redcedar. Only Douglas-fir was planted at marked points in the four lines per plot as at other study sites.

Soil surfaces were scalped just before planting of individual trees (fig. 9). Scalping involved the removal of slash, litter, humus, and any live vegetation to bare mineral soil from a spot at least 30 centimeters (1 ft) in diameter. Scalping is commonly done to provide a cleared surface around the opening made for planting the tree. It includes vegetation removal at the planting spot but not to the same extent as the "spot-clearing" site preparation that required live vegetation to be cut down within a 1.2-meter (4-ft) radius around the planted tree.

The premarked points in each plot were planted by experienced planters, members of the crew that planted the entire study area. Either two or four planters planted the four lines of premarked points. Planters were instructed to pull the stake and plant right where it had been, if possible. If not, they were to plant the tree as close as possible to the marked point. A few points were not plantable because of roots, rotten wood, and other obstacles; thus, plots started out with 104 to 120 marked trees per plot.

Figure 9—Before the tree was planted, the soil surface was scalped to clear slash, litter, humus, and live vegetation from a spot at least 30 centimeters (1 ft) in diameter. Note the new live vegetation at Camp 76 by March 23, 1981, after broadcast burning on September 4, 1980.

Figure 10—On the day planted, alternate trees in each plot were enclosed in plastic mesh tubes for protection from animals.

The same day trees in marked rows were planted and measured for size, every other tree was enclosed in an 8- by 75-centimeter (3- by 30-in) plastic mesh tube for protection from animals (fig. 10). The tube was fastened with paper-covered wire ties to a wooden lath that had been driven into the soil beside the tree. Tubes were firmly pushed down to achieve good contact with the soil surface all around the tree.

Neither the areas nor individual trees received release or any other postplanting treatment. Plastic tubes were left on protected trees to stretch and deteriorate as the trees developed.

Douglas-Fir Development

Information obtained on size, morphology, and vigor of the seedlings planted; on their survival and growth over a decade after different site preparation; and on amount and causes of damage and mortality is reported in this section.

Morphology of Nursery Stock

A handful of seedlings was taken from several bags of nursery stock as a representative sample of trees planted on each area. In the laboratory, 40 seedlings from each sample were measured, ovendried, and weighed to quantify their morphological characteristics.

Table 6—Morphology of the 2-0 Douglas-fir seedlings planted on each study area

	Study area				
Seedling characteristic	Formader	LBJ	Camp 76	Farmer	Average
	Mean, standard error, and data range				
Shoot:					
Length (centimeters)	41.9±1.5 25-69	31.0±0.8 17-47	33.6±0.6 25-43	52.3±1.2 38-72	39.7±0.9 17-72
Stem caliper (millimeters)—					
at ground level	5.6±0.2 3-10	4.5±0.2 3-7	4.0±0.1 2-7	9.2±0.4 5-17	5.8±0.2 2-17
at 15 centimeters	4.4±0.2 2-9	3.0±0.1 2-5	2.7±0.1 1-4	7.2±0.3 3-12	4.3±0.2 1-12
Lateral shoots (number)	14.2±0.8 6-29	12.8±0.6 6-22	5.6±0.6 0-21	18.8±0.9 9-30	12.8±0.5 0-30
Longest lateral (centimeters)	16.3±0.9 10-33	12.0±0.4 7-20	17.1±0.6 10-27	24.5±0.9 15-39	17.5±0.5 7-39
Dry weight (grams)	7.8±0.8 2.4-28.5	5.3±0.4 1.8-11.5	3.9±0.3 1.6-11.4	20.7±1.7 3.8-52.4	9.4±0.7 1.6-52.4
Roots:					
Tap root length (centimeters)	24.4±0.5 14-31	17.6±0.7 10-26	20.5±0.5 15-35	23.5±0.5 13-28	21.5±0.3 10-35
Dry weight (grams)	3.8±0.3 0.9-9.3	2.4±0.2 0.7-5.5	1.6±0.1 0.7-4.1	9.2±0.9 1.8-26.7	4.2±0.3 0.7-26.7
Total dry weight (grams)	11.6±1.1 3.3-36.0	7.7±0.6 2.9-16.2	5.5±0.4 2.6-15.5	29.8±2.6 5.7-72.6	13.6±1.0 2.6-72.6
Shoot/root ratio (dry weight basis)	2.1±0.1 0.8-3.8	2.4±0.1 1.4-3.6	2.4±0.1 1.5-4.3	2.4±0.1 1.3-4.3	2.3±0.1 0.8-4.3

The seedlings planted on the study areas differed substantially in size, weight, and shoot-root ratio (table 6). Shoots averaged 40 centimeters long, with those at LBJ (31 cm) the shortest and those at Farmer (52 cm) the longest. Stem caliper at ground level averaged 4.0 millimeters at Camp 76 and over twice that diameter at Farmer (9.2 mm). Number of lateral shoots 1 centimeter or longer averaged less than 6 on stock planted at Camp 76, but nearly 19 at Farmer; the longest lateral shoot was 30 centimeters. Root lengths were not as dissimilar as top lengths; averages ranged from 18 centimeters for LBJ stock to 24.4 centimeters for Formader stock.

There was a wide range in average shoot dry weight, from 3.9 grams at Camp 76 to 20.7 grams at Farmer; average root dry weight had a similar spread, from 1.6 to 9.2 grams. Seedlings at all locations had a good shoot-root ratio (dry weight basis), averaging from 2.1 at Formader to 2.4 at the other locations. In all attributes except trimmed root length, seedlings planted at Farmer were substantially larger and heavier than those planted on the other study areas.

Tree Survival

A brief examination in June of the first season revealed that the plantations were progressing satisfactorily at all four study areas. Sixty-seven percent of all marked Douglas-fir seedlings were alive and healthy, 9 percent were less than normal green, 17 percent were healthy but damaged, and 6 percent were already dead. There were more damaged and dead seedlings at Formader than elsewhere:

Area	Damaged	Dead
	Percent	
Formader	37.2	10.8
LBJ	5.7	6.4
Camp 76	4.5	6.6
Farmer	22.1	1.2
Average	17.3	6.3

Early mortality was less in the spray-and-burn plots than elsewhere, and more seedlings were damaged by June in burned plots than in unburned plots:

	Seedling status			
Site preparation	**Healthy**	**Below normal**	**Damaged**	**Dead**
		Percent		
None	65.7	14.0	14.0	6.3
Spot-clear	71.1	8.0	14.9	6.0
Spray	69.4	11.9	11.7	7.0
Burn	63.1	7.8	20.7	8.4
Slash and burn	64.6	9.1	19.5	6.9
Spray and burn	68.3	5.5	22.8	3.4
Average	67.0	9.3	17.3	6.3

Table 7—Decade-long survival of unprotected and protected Douglas-firs on each study area

Time and category	Study area: Formader No.	Percent	LBJ No.	Percent	Camp 76 No.	Percent	Farmer No.	Percent	All No.	Percent
At planting:	693	100.0	684	100.0	710	100.0	659	100.0	2,746	100.0
Unprotected	345	100.0	336	100.0	355	100.0	324	100.0	1,360	100.0
Protected	348	100.0	348	100.0	355	100.0	335	100.0	1,386	100.0
First year:	567	81.8	581	84.9	605	85.1	632	95.9	2,385	86.9
Unprotected	261	75.7	283	84.2	295	83.0	306	94.4	1,145	84.3
Protected	306	87.9	298	85.6	310	87.3	326	97.4	1,240	89.6
Second year:	523	75.4	542	79.1	561	78.9	615	93.4	2,241	81.7
Unprotected	231	66.8	262	77.8	260	73.1	291	89.9	1,044	76.9
Protected	292	83.9	280	80.5	301	84.7	324	96.8	1,197	86.5
Third year:	512	73.8	520	75.9	548	77.1	595	90.3	2,175	79.3
Unprotected	223	64.5	245	72.7	255	71.7	274	84.7	997	73.4
Protected	289	83.0	275	79.1	293	82.5	321	95.9	1,178	85.1
Fourth year:	503	72.5	511	74.6	539	75.8	583	88.4	2,136	77.8
Unprotected	217	62.8	241	71.5	249	70.0	265	81.8	972	71.5
Protected	286	82.1	270	77.6	290	81.6	318	95.0	1,164	84.1
Fifth year:	500	72.0	502	73.3	534	75.1	577	87.6	2,113	77.0
Unprotected	215	62.2	237	70.4	247	69.4	260	80.3	959	70.6
Protected	285	81.8	265	76.2	287	80.8	317	94.8	1,154	83.4
Seventh year:	494	71.2	495	72.3	529	74.4	569	86.3	2,087	76.0
Unprotected	212	61.4	231	68.6	244	68.6	255	78.8	942	69.3
Protected	282	81.0	264	75.9	285	80.2	314	93.8	1,145	82.7
Tenth year:	484	69.7	482	70.4	477	67.0	528	80.1	1,971	71.8
Unprotected	207	59.9	225	66.8	215	60.4	238	73.6	855	65.2
Protected	277	79.5	257	73.9	262	73.7	290	86.5	1,086	78.4

Unprotected seedlings had sustained more damage than did protected seedlings (14.0 vs. 3.3 percent) and also greater mortality (3.7 vs. 2.6 percent). Browsing and clipping were the main sources of early damage.

After 10 years, 71.8 percent of all the marked Douglas-firs were still alive (table 7). Nearly half (13.1 percent) of the total losses occurred in the first 10 months after planting and an additional 5.2 percent in the second year. Slow attrition from year 3 to 10 accounted for the remaining losses (9.9 percent).

Survival was 11 percent higher at Farmer than the average for the other study areas, perhaps attributable to the much larger planting stock used at this site. Throughout the decade, survival of all trees varied less than 4 percent among Formader, LBJ, and Camp 76; but Farmer was consistently higher by 10 to 18 percent (range: 7 to 23 percent for unprotected trees, 7 to 19 percent for protected trees).

Tree survival at 10 years differed significantly (P = 0.0124) among site-preparation treatments (fig. 11, appendix table 80). Without site preparation, survival of all trees averaged 54.5 percent, with site preparation from 63.5 to 81.3 percent. Tree survival after spot-clearing vegetation at planting time (63.5 percent) did not differ significantly at the 5-percent level of probability (Duncan's test) from no site preparation, spray, burn, or slash-and-burn preparation but differed significantly from spray-and-burn preparation (81.3 percent). Survival differences developed gradually; differences tested by analysis of variance as large as those observed among third-year means might occur by chance 15 percent of the time, by the fourth year, 8 percent, and by the seventh year, 6 percent of the time (table 8).

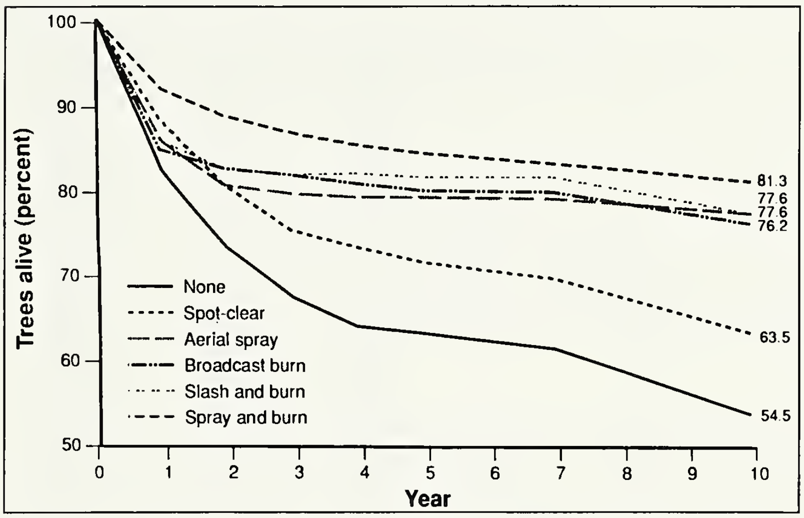

Figure 11—Average survival among all Douglas-firs for 10 years after each site preparation.

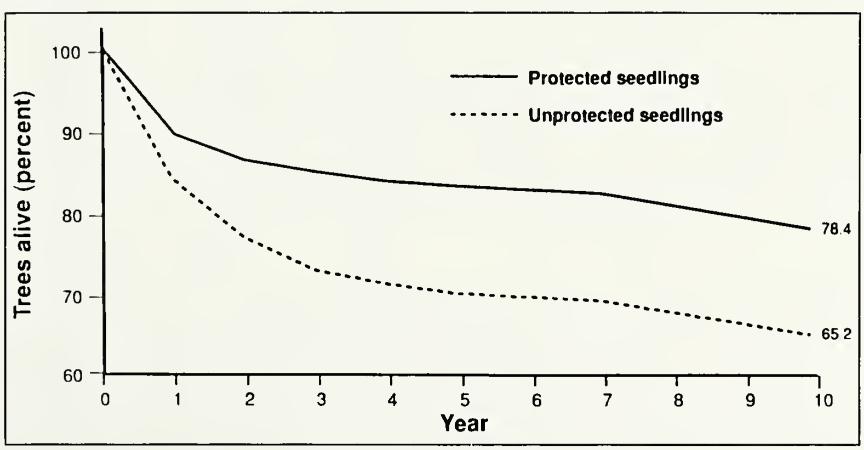

Figure 12—Decade-long survival of Douglas-firs unprotected or protected from animals by plastic mesh tubing.

Table 8—Significance of *F*-values for treatment sources of variation and orthogonal contrasts by variable and year

Variable and year	Sources of variation: Site preparation	Protection	Site preparation x protection	Orthogonal contrasts: No burn x burn	Control x treatment	No spray x spray
	P-values					
Tree survival:						
1	0.6980	0.0046	0.8383	0.5458	0.2995	0.3514
2	.4964	.0001	.2703	.1496	.1112	.2831
3	.1469	.0001	.0280	.0292	.0207	.1410
4	.0839	.0001	.0196	.0192	.0093	.1112
5	.0871	.0001	.0194	.0215	.0108	.1013
7	.0563	.0001	.0046	.0146	.0073	.0890
10	.0124	.0001	.0306	.0059	.0019	.0186
Total height:						
Initial	.6342	.3707	.3338	.4422	.8798	.9403
1	.7554	.0001	.9367	.6351	.9610	.1575
2	.4584	.0001	.8188	.0881	.5006	.5372
3	.1138	.0001	.9394	.0064	.0443	.6987
4	.0560	.0001	.9173	.0034	.0222	.5390
5	.0065	.0001	.8790	.0004	.0038	.3533
7	.0004	.0002	.3082	.0001	.0004	.0827
10	.0004	.0007	.4808	.0001	.0015	.1554
Stem caliper at 15 centimeters:						
Initial	.6279	.3970	.7897	.4964	.6644	.9135
1	.6104	.8369	.6358	.1772	.1752	.6767
2	.0632	.0006	.8349	.0042	.0254	.4412
3	.0058	.0010	.5752	.0004	.0058	.2148
4	.0014	.0587	.7856	.0002	.0023	.1316
5	.0001	.0084	.4893	.0001	.0004	.0540
7	.0001	.0005	.2079	.0001	.0001	.0020
10	.0002	.0001	.3945	.0001	.0004	.0518
Diameter at breast height:						
10	.0007	.0001	.5822	.0001	.0011	.0839

In orthogonal comparisons, survival averaged significantly higher (P = 0.0059) for burned plots (78.4 percent) than for those not burned (65.2 percent). Among nonburn methods, only for aerial spraying did seedling survival equal survival in broadcast burns. The survival average for all site preparation was significantly higher than that for no site preparation, and spray treatments combined averaged significantly higher than the average for the other four (table 8).

Substantially more trees protected by plastic mesh tubing survived (P = 0.0001) than did unprotected trees, 78 vs. 65 percent (fig. 12, appendix table 80). Most of the survival differences due to protection developed in the first 3 years; the gap widened by less than 2 percent from year 3 to 10. Survival differences between unprotected and protected trees were greatest in unburned areas; average differences ranged from 15 to 24 percent in unburned plots, 5 to 10 percent in burned plots.

Damage to Seedlings

Substantial numbers of seedlings were found damaged, seriously hindered, or dead from various causes at each examination (table 9, appendix table 81). During their first season after planting, 45 percent of the seedlings sustained damage or hindrance; in the second year, 34 percent; and 29 percent of second-year survivors sustained damage or hindrance in the third year. Such effects declined to 11 percent by year 7 but again reached nearly 50 percent when additional damage factors were added to the list for the 10th-year examination. Much seedling damage did not result in mortality, and many seedlings sustained damage more than once.

Browsing was the main source of seedling damage from the first through the fifth years, decreasing from 17 percent of all seedlings the first year to less than 4 percent of survivors by the fifth year. Stem clipping was the second leading cause of direct seedling injury. Overtopping from competing vegetation was rated an important, nondestructive hindrance, especially during the first 2 years (12 and 10 percent) and again in the 10th year as stands closed (overgrown plus shading = 23 percent). Almost 14 percent of trees alive in the 10th year had multiple stems that forked near the ground or higher in the crown.

The proportion of damaged seedlings found dead varied greatly among kinds of damage (table 9). In the first and second years, over half of the seedlings whose stems had been clipped were dead, whereas less than 2 percent of those browsed were dead (fig. 13). Over 10 percent of seedlings rated as overgrown in the first and second years were dead; in the 10th year, 35 percent of trees rated overgrown were dead. By the 10th year, tipping, caused by wind, weight of snow, and an insecure root system, became an important source of damage and mortality.

Substantial mortality occurred among seedlings that showed no evidence of physical damage. First-year mortality was 12.6 percent for visibly undamaged seedlings (table 9) and totaled 37 percent of all mortality over the decade (table 10). About 29 percent of all mortality was attributed to stem clipping and 25 percent to overtopping. Slightly less than 2 percent of all mortality occurred directly from browsing, but setbacks from browsing were often the cause for seedlings to later appear in the overgrown category.

Mortality among undamaged seedlings was nearly the same in all site-preparation treatments (5.2 to 7.4 percent) but differed by treatment in several damage categories (table 10). Mortality from stem clipping was higher in unburned areas than in burned areas, 19.5 vs. 9.0 percent of total mortality. Mortality caused by being overgrown was 11.5 percent of the total in unprepared sites, 6.2 percent in spot-clear sites, and 0.8 to 2.5 percent in the other treatments.

Table 9—Kinds of damage and associated mortality observed on tree seedlings at each examination

Kind of damage	Year 1 Damaged No.	Year 1 Damaged Percent	Year 1 Dead Percent	Year 2 Damaged No.	Year 2 Damaged Percent	Year 2 Dead Percent	Year 3 Damaged No.	Year 3 Damaged Percent	Year 3 Dead Percent	Year 4 Damaged No.	Year 4 Damaged Percent	Year 4 Dead Percent	Year 5 Damaged No.	Year 5 Damaged Percent	Year 5 Dead Percent	Year 7 Damaged No.	Year 7 Damaged Percent	Year 7 Dead Percent	Year 10 Damaged No.	Year 10 Damaged Percent	Year 10 Dead Percent
None	1,508	54.9[a]	12.6[b]	1,572	65.9	2.5	1,599	71.4	2.0	1,633	75.1	0.7	1,852	86.7	0.2	1,877	88.8	0.1	1,119	53.6	0.9
Stem clipped	205	7.5	55.1	128	5.4	57.0	122	5.4	22.1	37	1.7	13.5	18	.8	5.6	13	.6	15.4	0		
Browsed	479	17.4	2.3	306	12.8	.7	312	13.9	.6	257	11.8	0	76	3.6	0	39	1.8	0	4	.2	0
Trampled	1	+	0	2	.1	0	2	.1	0	5	.2	40.0	3	.1	0	0			0		
Bark injury	5	.2	0	3	.1	0	4	.2	0	5	.2	0	7	.3	0	11	.5	9.1	2	.1	0
Frosted	0			0			20	.9	0	0			1	+	0	8	.4	0	0		
Buried	41	1.5	2.4	18	.8	5.6	4	.2	25.0	5	.2	20.0	4	.2	25.0	2	.1	100.0	0		
Overgrown	320	11.7	12.8	239	10.0	11.7	105	4.7	1.0	157	7.2	8.3	152	7.1	10.5	142	6.7	9.9	238	11.4	35.3
In grass	5	.2	0	27	1.1	0	13	.6	0	27	1.2	0	2	.1	0	0			0		
Cage injury	0			29	1.2	0	33	1.5	0	19	.9	0	9	.4	11.1	6	.3	0	10	.5	0
Shaded[c]																			247	11.8	.8
Dieback[c]																			85	4.1	0
Whipped top[c]																			2	.1	0
Multiple stem[c]																			289	13.8	0
Chlorotic[c]																			21	1.0	0
Insect or disease[c]																			9	.4	11.1
Tipped over[c]																			61	2.9	31.1
Unidentified	182	6.6	2.7	61	2.6	1.6	27	1.2	11.1	30	1.4	20.0	12	.6	0	15	.7	40.0	0		
Total damaged and dead	1,238	45.1	29.2	813	34.1	17.7	642	28.6	10.3	542	24.9	7.2	284	13.3	8.1	236	11.2	11.0	968	46.4	12.0
Seedlings alive	2,385			2,241			2,175			2,136			2,113			2,087			1,971		
Periodic mortality			13.1			6.0			2.9			1.8			1.1			1.2			5.6
Cumulative mortality			13.1			18.4			20.8			22.2			23.1			24.0			28.2

[a] Percentage damage based on total trees alive at beginning of time period.
[b] Percentage mortality based on total damaged trees in that category.
[c] These kinds of damage observed in year 10 only.

Figure 13—Many seedlings were browsed, but less than 2 percent of all mortality was attributed directly to browsing damage as sustained by these 4-year-old trees at Formader.

Table 10—Total mortality in each site-preparation treatment and damage category, years 1 to 10

Kind of damage	Site preparation													
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn		All	
	No.	*Percent*	*No.*	*Percent*	*No.*	*Percent*	*No.*	*Percent*	*No.*	*Percent*	*No.*	*Percent*	*No.*	*Percent*
None	50	6.5	42	5.4	48	6.2	57	7.4	51	6.6	40	5.2	288	37.2
Stem clipped	55	7.1	61	7.9	35	4.5	24	3.1	30	3.9	16	2.1	221	28.5
Browsed	2	.3	4	.5	3	.4	4	.5	1	.1	1	.1	15	1.9
Trampled	0		0		2	.3	0		0		0		2	.3
Bark injury	0		0		0		0		0		1	.1	1	.1
Buried	1	.1	2	.3	2	.3	0		0		2	.3	7	.9
Overgrown	89	11.5	48	6.2	6	.8	19	2.5	19	2.5	16	2.1	197	25.4
Cage injury	0		0		0		0		0		1	.1	1	.1
Shaded	0		0		1	.1	0		1	.1	0		2	.3
Insect or disease	0		1	.1	0		0		0		0		1	.1
Tipped over	2	.3	7	.9	1	.1	7	.9	0		2	.3	19	2.5
Unidentified	4	.5	4	.5	3	.4	1	.1	0		9	1.2	21	2.7
Total	203	26.2	169	21.8	101	13.0	112	14.5	102	13.2	88	11.4	775	100.0

Sixty-one percent of all mortality occurred among unprotected seedlings, 39 percent among protected seedlings; but the proportions were different in several damage categories (table 11). More protected than unprotected seedlings died among those that sustained no visible damage; perhaps a 15-percent difference reflects the effect of crowding, or competition within, or tilting of the plastic mesh tube as well as differential depletion of seedlings from the nondamage category. Ninety-four percent of all mortality associated with clipping damage was sustained by unprotected seedlings, as was 87 percent associated with browsing, and 67 percent of all unidentified mortality.

Table 11—Total mortality (TM) and percentage mortality by kind of damage found among unprotected (UNP) and protected (PRO) seedlings at each examination

Kind of damage	Year examined: 1 TM	1 UNP	1 PRO	2 TM	2 UNP	2 PRO	3 TM	3 UNP	3 PRO	4 TM	4 UNP	4 PRO	5 TM	5 UNP	5 PRO	7 TM	7 UNP	7 PRO	10 TM	10 UNP	10 PRO	Total TM	Total UNP	Total PRO
	No.	– Percent –		No.	– Percent –		No.	– Percent –		No.	– Percent –		No.	– Percent –		No.	– Percent –		No.	– Percent –		No.	– Percent –	
None	190	22.4	30.2	39	8.3	18.8	32	25.8	22.7	12	15.4	15.4	4	0.0	17.4	1	0.0	3.9	10	5.2	3.5	288	42.4	57.6
Stem clipped	113	29.9	1.4	73	47.2	3.5	27	37.9	3.0	5	12.8	0.0	1	4.4	0.0	2	3.9	3.9	0			221	94.1	5.9
Browsed	11	2.5	0.6	2	1.4	0.0	2	3.0	0.0	0			0			0			0			15	86.7	13.3
Trampled	0			0			0			2	2.6	2.6	0			0			0			2	50.0	50.0
Bark injury	0			0			0			0			0			1	3.9	0.0	0			1	100.0	0
Buried	1	0.3	0.0	1	0.0	0.7	1	0.0	1.5	1	2.6	0.0	1	0.0	4.4	2	7.7	0.0	0			7	57.1	42.9
Overgrown	41	3.6	7.8	28	12.5	6.9	1	1.5	0.0	13	20.5	12.8	16	52.2	17.4	14	34.6	19.2	84	33.6	38.8	197	50.8	49.2
Cage Injury	0			0			0			0			1	0.0	4.4	0			0			1	0	100.0
Shaded[a]																			2	0.9	0.9	2	50.0	50.0
Insect or disease[a]																			1	0.9	0.0	1	100.0	0
Tipped over[a]																			19	8.6	7.8	19	52.6	47.4
Unidentified[a]	5	0.8	0.6	1	0.7	0.0	3	3.0	1.5	6	10.3	5.1	0			6	15.4	7.7	0			21	66.7	33.3
Total dead	361	59.6	40.4	144	70.1	29.9	66	71.2	28.8	39	64.1	35.9	23	56.5	43.5	26	65.4	34.6	116	49.1	50.9	775	61.3	38.7
Cum. mort.		7.8	5.3		11.5	6.9		13.2	7.6		14.1	8.1		14.6	8.4		15.2	8.8		17.3	10.9		17.3	10.9

[a] These kinds of damage observed in year 10 only.

Table 12—Total mortality (TM) and percentage mortality by kind of damage found among unprotected (UNP) and protected (PRO) seedlings in each site-preparation treatment, years 1 to 10

	Site preparation																				
	None			Spot-clear			Spray			Burn			Slash and burn			Spray and burn			All		
Kind of damage	TM	UNP	PRO	TM	UNP	PRO	TM	UNP	PRO	TM	UNP	PRO	TM	UNP	PRO	TM	UNP	PRO	TM	UNP	PRO
	No.	– *Percent* –		*No.*	– *Percent* –		*No.*	– *Percent* –		*No.*	– *Percent* –		*No.*	– *Percent* –		*No.*	– *Percent* –		*No.*	– *Percent* –	
None	50	3.0	3.5	42	2.3	3.1	48	2.8	3.4	57	2.5	4.9	51	3.0	3.6	40	2.2	3.0	288	15.7	21.4
Stem clipped	55	6.6	.5	61	7.2	.6	35	4.5	0	24	2.8	.3	30	3.6	.3	16	2.1	0	221	26.8	1.7
Browsed	2	.1	.1	4	.4	.1	3	.4	0	4	.5	0	1	.1	0	1	.1	0	15	1.7	.3
Trampled	0			0			2	.1	.1	0			0			0			2	.1	.1
Bark injury	0			0			0			0			0			1	.1	0	1	.1	0
Buried	1	.1	0	2	.3	0	2	.1	.1	0			0			2	0	.3	7	.5	.4
Overgrown	89	4.8	6.7	48	3.5	2.7	6	.4	.4	19	1.5	.9	19	1.3	1.2	16	1.4	.6	197	12.9	12.5
Cage injury	0			0			0			0			0			1	0	.1	1	0	.1
Shaded	0			0			1	.1	0	0			1	0	.1	0			2	.1	.1
Insect or disease	0			1	.1	0	0			0			0			0			1	.1	0
Tipped over	2	.1	.1	7	.4	.5	1	0	.1	7	.6	.3	0			2	.1	.1	19	1.3	1.2
Unidentified	4	.4	.1	4	.3	.3	3	.3	.1	1	0	.1	0			9	.9	.3	21	1.8	.9
Total	203	15.1	11.1	169	14.5	7.4	101	8.8	4.3	112	8.0	6.5	102	8.0	5.2	88	7.0	4.4	775	61.3	38.7

The significant survival interaction between site preparation and protection (see table 8) seems attributable to some disproportionate responses of unprotected and protected seedlings to site preparation rather than to any major anomaly (table 12). For example, 62.5 percent of all mortality among unprotected seedlings occurred in unburned areas, 37.5 percent in burned areas; for protected seedlings the proportions were closer, 58.6 and 41.1 percent. Among overgrown seedlings, more protected than unprotected seedlings died on areas without site preparation, but in site-prepared areas, mortality of unprotected seedlings was equal or greater than for protected seedlings. Noteworthy, but without any apparent bearing on the interaction—among undamaged seedlings, mortality was greater for protected than for unprotected seedlings in every site-preparation treatment.

Height Growth

Average total height of seedlings increased by 637 centimeters in a decade, from 43 to 680 centimeters (table 13). Seedlings averaged tallest at LBJ (715 cm) even though these had averaged shortest initially. At Farmer, seedlings that were tallest initially now ranked third among study sites (665 cm). The difference in average total height between LBJ and Farmer widened slightly up to the third year, then narrowed by the fifth year, and flip-flopped by the seventh year as site differences apparently overrode differences in initial seedling size. The shortest 10-year-old live tree was 30-centimeters tall and the tallest 1235 centimeters tall, both at Camp 76.

Most site-preparation methods enhanced the height growth of trees (fig. 14, appendix table 82). Average total height at 10 years ranged from 592 centimeters on unprepared sites to 756 centimeters on the broadcast-burned sites. Average tree height was actually shortest on sites spot-cleared manually (582 cm), but the mean

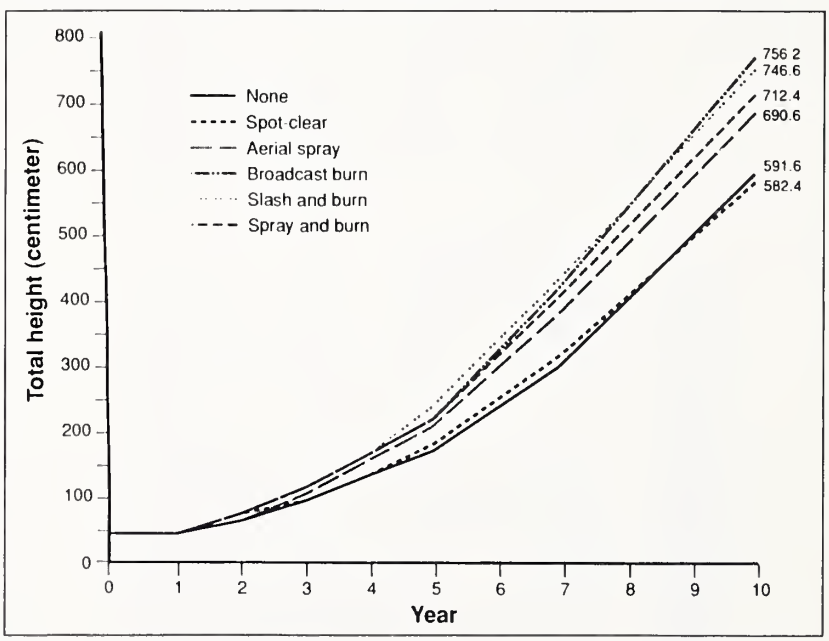

Figure 14—Average total height attained by all Douglas-firs in 10 years after each site preparation.

Table 13—Periodic total height of Douglas-fir at each study area

Time and category	Formader	LBJ	Camp 76	Farmer	All
	Study area				
	Mean and standard error (centimeters)				
At planting:	42.1±0.5	37.1±0.8	39.3±0.6	52.1±0.7	42.6±0.9
Unprotected	41.7±0.6	37.4±1.1	39.2±0.9	52.9±0.9	42.8±1.3
Protected	42.4±0.9	36.8±1.1	39.4±0.8	51.3±1.2	42.5±1.2
First year:	45.4±1.8	45.2±1.4	44.0±0.9	62.0±1.4	49.1±1.3
Unprotected	39.8±0.9	42.8±1.4	41.9±1.0	58.3±1.1	45.7±1.6
Protected	50.9±0.9	47.5±2.3	46.1±0.9	65.8±1.3	52.6±1.8
Second year:	58.3±3.3	70.4±2.6	62.6±3.3	93.0±4.6	71.1±2.6
Unprotected	48.3±2.2	63.7±1.8	53.2±3.4	81.9±5.0	61.8±3.1
Protected	68.4±1.9	77.1±3.0	72.0±1.5	104.2±4.4	80.4±3.2
Third year:	83.0±5.1	117.5±5.4	101.1±5.0	135.6±6.9	109.3±3.9
Unprotected	72.0±6.4	110.4±5.6	85.9±3.6	122.7±9.3	97.8±5.2
Protected	93.9±5.0	124.6±8.6	116.4±2.1	148.5±7.4	120.8±5.0
Fourth year:	120.0±7.9	172.3±8.4	154.6±6.8	185.4±9.1	158.0±5.3
Unprotected	108.6±11.2	164.5±9.9	134.9±5.7	172.5±13.6	145.1±7.2
Protected	131.4±9.7	180.2±13.6	174.3±4.3	198.2±10.7	171.0±7.0
Fifth year:	165.8±11.9	230.8±11.3	215.7±9.2	241.5±11.1	213.4±6.8
Unprotected	152.1±17.3	225.6±14.6	193.7±10.4	230.2±16.9	200.4±9.6
Protected	179.4±15.8	236.1±18.4	237.6±8.6	252.7±14.4	226.5±9.0
Seventh year:	339.8±20.9	409.0±19.4	401.5±16.7	393.4±16.2	385.9±9.8
Unprotected	321.3±30.1	407.6±24.0	374.3±22.6	384.3±22.1	371.9±13.4
Protected	358.2±29.8	410.4±32.8	428.7±20.6	402.5±25.2	399.9±13.9
Tenth year:	658.4±28.7	715.2±25.4	680.9±22.7	665.3±25.5	680.0±12.8
Unprotected	641.1±42.5	713.7±31.6	635.4±28.7	651.6±35.2	660.4±17.5
Protected	675.8±41.2	716.8±42.9	726.4±25.0	679.0±39.4	699.5±18.2

difference from no site preparation was not significant at the 5-percent probability level. Height differences also developed gradually, there being no significant difference at the 5-percent level until about the fourth year, or at the 1-percent level until the fifth year (table 8).

Total height averaged significantly greater (P = 0.0001) for burned plots (738.4 cm) than for unburned plots (621.5 cm). Tree heights for plots aerially sprayed were intermediate to those burned and those manually spot-cleared or left unprepared.

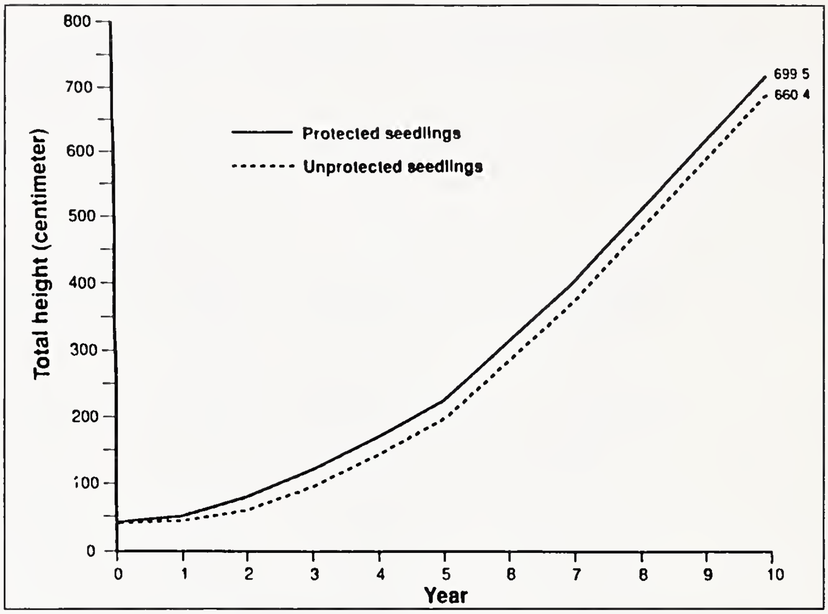

Figure 15—Average total height attained in 10 years by unprotected and protected Douglas-firs.

Seedlings protected by plastic mesh tubing averaged 6 percent taller (P = 0.0007) at 10 years than those left unprotected (fig. 15, appendix table 82). Height differences between protected and unprotected trees averaged 15 percent at the end of the first season, increased to 30 percent the second season, and from then on the gap has narrowed. Unlike the pattern for seedling survival, height for protected and unprotected trees showed no consistency in the magnitude of differences among site-preparation treatments. In the spot-cleared treatment, protected trees averaged 3.5 centimeters shorter than unprotected trees.

Diameter Growth

Average stem caliper at 15 centimeters above mean ground level increased by 130 millimeters in a decade, from 5 to 135 millimeters (table 14). Average stem caliper at 10 years was greater at Formader (152 mm) than at LBJ (146 mm) which had the tallest trees and less at Farmer (127 mm) whose trees had the largest stem caliper initially (7.4 mm). Stem caliper at 10 years ranged from a minimum of 8 millimeters for a tree at LBJ to 298 millimeters for one at Formader.

Of the 1,971 trees alive at 10 years, all but 27 had grown tall enough to have a diameter at breast height. They averaged 103 millimeters and ranged from 111 millimeters at Formader to 91 millimeters at Camp 76 (table 14). The smallest d.b.h. for an individual tree was 6 millimeters at Camp 76 and the largest 224 millimeters for one at LBJ.

Table 14—Periodic stem caliper at 15 centimeters and 10th-year d.b.h. of Douglas-fir at each study area

Time and category	Study area: Formader	LBJ	Camp 76	Farmer	All
	Mean and standard error (millimeters)				
At planting:	4.9±0.1	4.8±0.1	3.8±0.1	7.4±0.1	5.2±0.2
Unprotected	4.8±0.1	4.8±0.1	3.8±0.1	7.5±0.1	5.2±0.3
Protected	4.9±0.1	4.7±0.2	3.8±0.1	7.2±0.1	5.2±0.3
First year:	6.0±0.2	5.5±0.2	4.7±0.1	9.2±0.2	6.4±0.3
Unprotected	5.8±0.1	5.6±0.2	4.7±0.1	9.5±0.2	6.4±0.4
Protected	6.3±0.3	5.4±0.3	4.7±0.1	9.0±0.2	6.4±0.4
Second year:	9.1±0.4	8.1±0.3	7.2±0.2	13.1±0.5	9.4±0.4
Unprotected	8.3±0.5	8.0±0.4	6.8±0.2	12.9±0.8	9.0±0.5
Protected	9.9±0.5	8.2±0.5	7.6±0.3	13.2±0.6	9.7±0.5
Third year:	14.0±0.9	13.4±0.8	11.9±0.5	19.4±1.1	14.7±0.6
Unprotected	13.0±1.2	13.3±1.0	11.1±0.7	19.0±1.8	14.1±0.8
Protected	14.9±1.2	13.5±1.3	12.7±0.7	19.8±1.5	15.3±0.8
Fourth year:	21.1±1.4	22.3±1.6	18.7±0.9	28.1±1.9	22.5±0.9
Unprotected	20.1±2.1	22.6±2.3	17.7±1.3	27.9±3.0	22.1±1.3
Protected	22.0±2.0	22.1±2.5	19.7±1.4	28.3±2.7	23.0±1.2
Fifth year:	30.2±2.2	33.7±2.5	26.8±1.5	39.3±2.7	32.5±1.3
Unprotected	28.9±3.1	33.9±3.6	25.1±2.1	38.5±4.0	31.6±1.9
Protected	31.6±3.2	33.5±3.9	28.5±2.1	40.1±4.0	33.4±1.8
Seventh year:	66.1±4.5	70.6±4.9	58.6±3.9	70.0±4.2	66.3±2.2
Unprotected	62.8±6.0	70.2±6.1	53.4±5.4	68.5±5.7	63.7±3.0
Protected	69.5±6.9	71.0±8.2	63.9±5.2	71.5±6.6	69.0±3.2
Tenth year:	152.1±6.3	146.3±6.4	114.9±4.8	126.7±7.5	135.0±3.7
Unprotected	144.4±8.0	145.5±7.5	104.4±6.0	122.0±10.3	129.1±5.2
Protected	159.8±9.4	147.1±11.0	125.4±4.5	131.4±11.4	140.9±5.2
D.b.h., year 10:	110.9±4.8	110.1±4.4	90.6±3.4	98.3±4.7	102.5±2.4
Unprotected	105.7±7.0	109.1±5.2	83.0±3.9	94.2±6.5	98.0±3.5
Protected	116.0±6.5	111.1±7.7	98.3±3.3	102.3±6.8	106.9±3.3

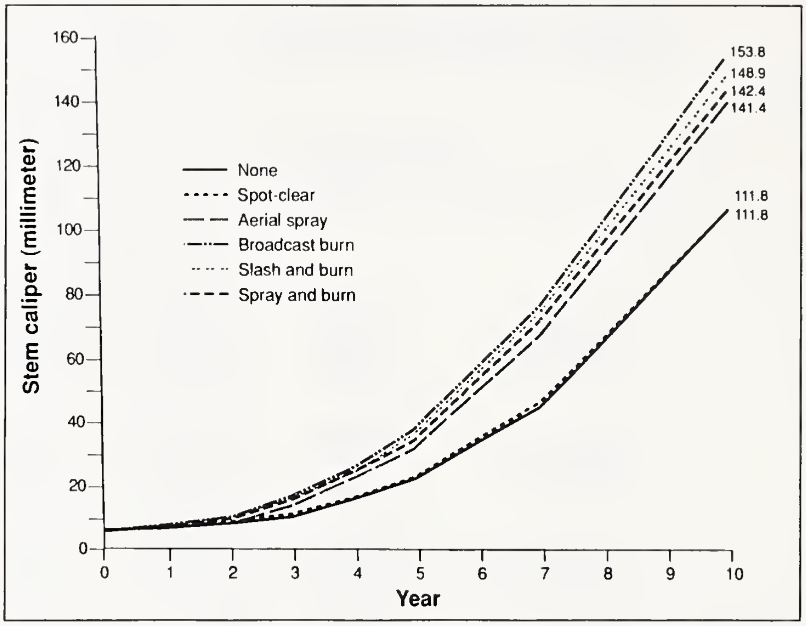

Figure 16—Average stem caliper at 15 centimeters aboveground attained by all Douglas-firs in 10 years after each site preparation.

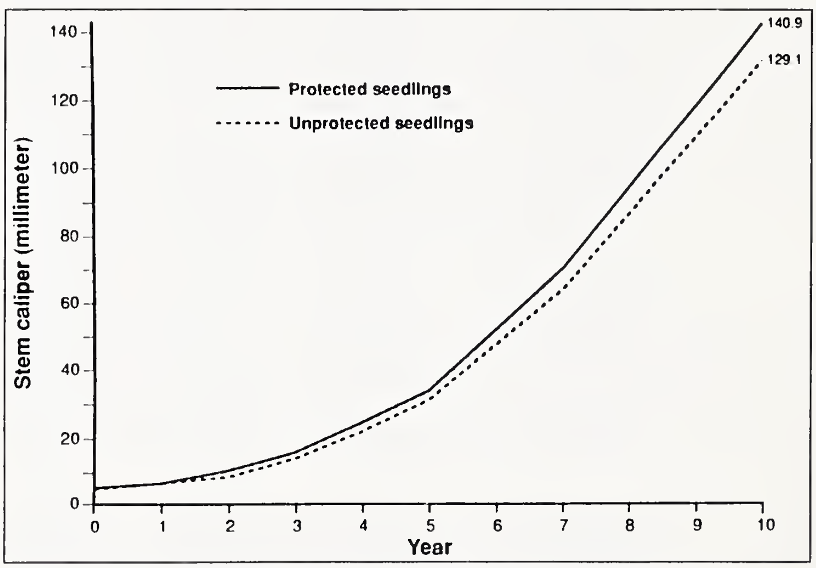

Figure 17—Average stem caliper at 15 centimeters aboveground attained in 10 years by unprotected and protected Douglas-firs.

Stem caliper development was significantly affected (P = 0.0002) by site preparation (fig. 16, appendix table 83). Stem caliper development after no site preparation or spot clearing was identical (112 mm) but significantly less than for the other four site-preparation treatments (141 to 154 mm). Stem caliper differences became evident at the 5-percent probability level after the second season and became more distinctive thereafter (table 8). The same site-preparation influences are evident in the 10th-year d.b.h. comparisons.

Stem caliper and d.b.h. differed significantly between burned and unburned plots (P = 0.0001), between averages for treated and control plots (P = 0.0004 and 0.0011), and between sprayed plots and those not sprayed (P = 0.0518 and 0.0839). Again, results for sprayed plots were more like those for burned plots than for those manually spot-cleared or left unprepared.

Seedlings protected by plastic mesh tubing averaged 9 percent larger in stem caliper and d.b.h. (P = 0.0001) than those left unprotected (fig. 17, appendix table 83). Average stem caliper of protected and unprotected trees was identical at planting and at the end of the first year but differed consistently thereafter by 4 to 9 percent. Stem caliper and d.b.h. of protected trees was consistently greater than for unprotected trees in each site-preparation treatment, but the magnitude of the differences differed and showed no clear pattern.

Stand Fractions

There are at least two reasons to compare fractional parts of the stands that developed after site preparation: (1) a disproportionate distribution of large or small trees in one treatment or another could have affected the relative ranking of site-preparation effects, and (2) because the smaller trees are not likely to survive as crop trees as each stand closes, the 10-year dimensions of the larger trees best describe the stand that now is dominant in each treatment and that will provide the main components in the future (fig. 18).

A B

Figure 18—Between 7 and 10 years after burning or spraying, well-stocked stands closed rapidly; those produced after spot clearing or no site preparation are now more patchy and open. (A) Seven-year-old stand after slash-and-burn treatment at Camp 76. (B) Open 10-year-old stand resulting from no site preparation in foreground, more closed stand from site preparation with glyphosate in background at LBJ.

Comparisons based on stand fractions representing the tallest 90, 75, and 50 percent of the trees did not reveal any major shifts in the ranking of means nor in the significance of differences among stands produced by different site preparation (table 15). There were some minor shifts in ranking and in the magnitude of differences between means that changed the significance among means at the 5- or 1-percent probability level. The comparisons seem to identify these characteristics about the stands:

- In the burn and slash-and-burn treatments, the tallest 50 percent of the trees averaged nearly the same in height and stem caliper. Therefore, the nonsignificant 9.6-centimeter mean difference in total height and 4.9-millimeter mean difference in stem caliper between the whole stands of these two treatments occurred mostly in the smaller half of the trees.
- When the shortest 10, 25, or 50 percent of the trees are not in the data, then stem caliper at 15 centimeters averaged slightly more for stands from spot-clearing than for stands resulting from no site preparation; likewise for total height when comparing only the tallest 50 percent of each stand. Apparently, the stands that developed after spot-clearing had some short, small caliper trees that unduly affected the whole stand mean relative to the mean representing no site preparation.
- Stem caliper rankings for the spray and spray-and-burn treatments reverse as smaller fractional parts of the stand are considered. Among trees in the shorter fraction, those that developed after spraying apparently have smaller stem calipers than those in spray-and-burn stands.
- When only trees with a d.b.h. are considered, reversals in ranking occur among the top four treatments only when the taller halves of the stands are compared. Again, differences in the smaller-tree component had a minor influence on relative standing among treatments in whole stand comparisons.

Whether the averages for the whole stand or for fractional parts are compared, unprepared sites and spot-cleared sites produced distinctly smaller stands than did the other site-preparation methods.

Comparing sizes for the whole stand to the dominant half, average height changes from 680 to 803 centimeters, average stem caliper at 15 centimeters from 135 to 162 millimeters, and average d.b.h. from 103 to 122 millimeters. The dominant half of the stand is nearly one-fifth larger in these dimensions than is the whole stand. Minimum size of tree changed dramatically—total height from 30 to 527 centimeters, stem caliper from 8 to 52 millimeters, and minimum d.b.h. from 6 to 49 millimeters. The minimum-sized trees occurred in the no-preparation and spot-clear treatments; maximum sizes occurred in the other four treatments.

Relative Yields and Costs

In the decade since site preparation, different numbers and sizes of trees were produced by each treatment, and the costs involved also differed substantially. Significant gains in survival and growth also were obtained by use of plastic mesh tubing, but such tree protection may equal or exceed the cost of planting. To compare results in useful, integrated terms, survival and growth data were used to calculate cubic volumes produced per acre; and both volumes and costs were expressed as ratios relative to no site preparation.

Table 15—Average dimensions of 10-year-old trees for fractions of the stand in each site preparation

Site preparation	Mean for a stand fraction and its ranking (R)							
	All		Tallest 90 percent		Tallest 75 percent		Tallest 50 percent	
	Mean	*Rank*	*Mean*	*Rank*	*Mean*	*Rank*	*Mean*	*Rank*
				Total height (centimeters)				
None	591.6By[a]	5	622.7By	5	669.1By	5	723.4By	6
Spot-clear	582.4By	6	621.6By	6	666.8By	6	725.4By	5
Spray	690.6ABz	4	726.8ABz	4	762.4ABz	4	818.5ABz	4
Burn	756.2Az	1	786.0Az	1	816.0Az	1	862.3Az	2
Slash and burn	746.6Az	2	776.8Az	2	812.8Az	2	862.9Az	1
Spray and burn	712.4Az	3	743.1Az	3	778.4Az	3	828.1ABz	3
Average	680.0		712.8		750.9		803.4	
				Stem caliper at 15 centimeters aboveground (millimeters)				
None	111.8B	5	118.3B	6	128.5By	6	141.9Bx	6
Spot-clear	111.8B	5	119.2B	5	129.8By	5	145.7Bxy	5
Spray	141.4A	4	148.4A	4	156.0ABz	3	169.0ABz	3
Burn	153.8A	1	161.0A	1	166.5Az	1	174.2Az	2
Slash and burn	148.9A	2	155.3A	2	163.4Az	2	176.4Az	1
Spray and burn	142.4A	3	149.0A	3	155.5ABz	4	164.3ABzy	4
Average	135.0		141.9		150.0		161.9	
				Diameter breast high (millimeters)				
None	86.5B	6	89.8B	6	97.4Cy	6	107.0Cy	6
Spot-clear	87.4B	5	90.4B	5	98.7BCy	5	110.2BCy	5
Spray	105.9A	4	110.8A	4	116.7ABz	4	126.8ABz	3
Burn	113.8A	1	118.8A	1	123.1Az	1	129.4ABz	2
Slash and burn	112.8A	2	117.1A	2	123.1Az	1	132.2Az	1
Spray and burn	108.2A	3	113.4A	3	118.3Az	3	125.0ABz	4
Average	102.5		106.7		112.9		121.8	

[a] Means followed by the same capital letter or lower case letter do not differ significantly by Duncan's test—capital letters denote 0.01 probability level or less; lower case letters denote 0.05 probability level and are shown only if the significance rankings differ at the 2 probability levels.

The comparisons were developed by using recent costs of these site-preparation practices as a reforestation expense rather than as a capital investment. Costs differ greatly for the same practice from time to time and from place to place for many reasons: whether the work is contracted out or done in-house, whether done on public or private land, the size and location of the area, and the constraints and anticipated interruptions. Midrange values for each practice generally were used (appendix table 84). Some site-preparation practices facilitate planting, tubing, and inspection; others do not. An adjustment was included if a practice requires more advance preparation or followup than others as, for example, spraying or if site preparation facilitates subsequent planting and tubing as does broadcast burning. The estimated volumes, the relative costs, and the relative gains for each method were calculated as if 400 trees per acre comprised full (100-percent) stocking.

Table 16—Volume per acre at age 10 for stands resulting from different site preparation

Site preparation	Average height	Average stem caliper	Average volume per tree	Survival	Trees per acre	Volume per acre	Relative volume
	Stand characteristic						
	Centimeters	*Millimeters*	*Cubic centimeters*	*Percent*	*Number*	*Cubic meters*	
			Unprotected seedlings				
None	568.6	106.0	16 725.8	47.0	188.0	3.144 45	1.00
Spot-clear	584.1	110.5	18 671.5	51.3	205.2	3.831 40	1.22
Spray	664.4	132.1	30 353.1	69.7	278.8	8.462 45	2.69
Burn	725.3	144.5	39 648.0	73.7	294.8	11.688 24	3.72
Slash and burn	729.4	142.6	38 830.5	72.7	290.8	11.291 91	3.59
Spray and burn	690.9	138.8	34 846.8	76.7	306.8	10.690 99	3.40
			Protected seedlings				
None	614.7	117.5	22 218.1	62.0	248.0	5.510 09	1.00
Spot-clear	580.6	113.0	19 409.0	75.7	302.8	5.877 03	1.07
Spray	716.9	150.6	42 567.4	85.6	342.4	14.575 07	2.65
Burn	787.0	163.1	54 808.9	78.8	315.2	17.275 76	3.14
Slash and burn	763.8	155.2	48 165.0	82.6	330.4	15.913 71	2.89
Spray and burn	733.9	146.0	40 955.4	85.8	343.2	14.055 88	2.55

Table 17—Volume per acre at age 10 and return relative to cost of site preparation

Site preparation	Volume per acre, cubic meters	Ratio: preparation vs. no preparation		
		Volume	Cost	Return[a]
		Unprotected seedlings		
None	3.14	1.00	1.00	1.00
Spot-clear	3.83	1.22	1.91	.64
Spray	8.46	2.69	1.51	1.78
Burn	11.69	3.72	1.61	2.31
Slash and burn	11.29	3.59	2.08	1.73
Spray and burn	10.69	3.40	2.23	1.52
		Protected seedlings		
None	5.51	1.00	1.00	1.00
Spot-clear	5.88	1.07	1.44	.74
Spray	14.58	2.65	1.24	2.14
Burn	17.28	3.14	1.21	2.60
Slash and burn	15.91	2.89	1.44	2.01
Spray and burn	14.06	2.55	1.51	1.69

[a] Volume ratio divided by cost ratio.

The volume of stemwood produced per acre in the first 10 years varied substantially after different site preparation (fig. 1, table 16). Relative to no preparation, site preparation involving broadcast burning produced 2.9 times more volume when trees were protected by tubing and 3.6 times more volume when trees were unprotected. Site preparation by aerial spraying produced about 2.7 times more volume than no site preparation. Spot-clearing yielded a 22-percent gain for unprotected trees and only a 7-percent gain for protected trees relative to no site preparation.

Broadcast burning yielded the highest volume return relative to expenditures made above the base costs associated with no site preparation (table 17). Three other site-preparation methods—slash and burn, spray and burn, and spraying alone—also yielded large returns, but manually clearing around individual planting spots cost more relative to the yield produced than no site preparation at all.

Protecting seedlings with plastic mesh tubing after planting resulted in substantial volume gain for every site preparation:

	Volume per acre		
Site preparation	**Unprotected trees**	**Protected trees**	**Gain**
	- - - - - *Cubic meters* - - - - -		*Percent*
None	3.14	5.51	75
Spot-clear	3.83	5.88	54
Aerial spray	8.46	14.58	72
Broadcast burn	11.69	17.28	48
Slash and burn	11.29	15.91	41
Spray and burn	10.69	14.06	32

Judging by the gains produced, seedlings required and benefited more from protection when slash remained than when it was removed by burning.

Vegetation Dynamics

During the study, vegetation transects were examined eight times with occurrence, cover, and height of dominant individual species or closely related groups recorded for each transect. The lineal length of transects examined each time totaled 6912 meters (22,677 ft) or 288 meters (945 ft) per plot, 1152 meters (3,780 ft) per site preparation, and 1728 meters (5,669 ft) per location. A species might be found dominant and measured at several places along an individual transect. These separate measurements were summed so that a species was represented on the transect by a single occurrence, cover value, and height.

The large quantities of vegetation data have been organized to provide a summary of the species found, an overview of broad cover trends and area variations, the rate and composition of successional trends without and with site preparation, effects on species diversity, and the response of individual species to the different site preparations.

Species Found

Fifty-six individual species or groups were tallied and kept identified in summarizing vegetation data (table 18). Woody species were individually identified with all but four exceptions—young plants of blue and red elder (*Sambucus* spp.) were not separately identified, nor were infrequently occurring species of *Berberis, Prunus*, and *Salix*. Almost half the herbaceous species were tallied and summarized by genus groupings. In summarizing woody and herbaceous cover, all perennial vines were classed as woody, all ferns as herbaceous. To the category "miscellaneous herbaceous" was assigned a large variety of plants that appeared infrequently in dominant positions including bedstraw (*Galium* spp.), chickweed (*Cerastium* spp.), solomon seal (*Smilacina* spp.), vanillaleaf (*Achlys*), and vetch (*Vicia* spp.).

Thirty-three woody species or groups were found as dominants on the study areas—5 conifer and 10 deciduous trees, 4 evergreen and 10 deciduous shrubs, and 4 vine or cane species (table 18). The 23 herbaceous species or groups included 11 genus groupings, 5 individual species, 5 ferns, 1 herbaceous vine, and a catchall group.

Several species were found so infrequently or incidentally, they could hardly be considered even a minor component of the dominant vegetation these study areas represent:

Abies grandis—A 164-centimeter tall tree found only on one transect at Farmer before site preparation by broadcast burning.

Amelanchier florida—Dominant only in 1983 on two transects (frequency 0.4, cover 0.1 percent) in the plot without site preparation at Camp 76. Their heights were 178 and 200 centimeters.

Baccharis pilularis—Found as a 12-centimeter dominant on one slash-and-burn transect at Camp 76 in 1982 and as a 210-centimeter dominant on one slash-and-burn transect at Farmer in 1987. These were northerly occurrences of a species that is more prominent south of the study areas.

Quercus garryana—Dominant as a 21-centimeter tree on a single slash-and-burn transect at Formader in 1981, an apparent occurrence of this species far outside of its reported natural range.

***Salix* spp.**—Found dominant (160 and 220 cm) on two undisturbed transects at Camp 76 in 1982 and on one sprayed transect (height, 58 cm) in 1983. These were north slope locations away from a stream bank, an uncommon place for willow to be found.

Thuja plicata—Dominant on a single spray-and-burn transect at Camp 76 in 1985. A native species planted on this area but usually not close to these transects.

Vaccinium membranaceum—Found only on one transect at Farmer before site preparation by broadcast burning (height, 45 cm).

Table 18—Species and groups tallied in repeated vegetation examinations

Scientific name	Abbreviation	Common name
Abies grandis (Dougl. ex D. Don) Lindl.	ABGR	Grand fir
Acer circinatum Pursh	ACCI	Vine maple
Acer macrophyllum Pursh	ACMA	Bigleaf maple
Adiantum pedatum L.	ADPE	Maidenhair fern
Alnus rubra Bong.	ALRU	Red alder
Amelanchier florida Lindl.	AMFL	Pacific serviceberry
Anaphalis margaritacea (L.) B. & H.	ANMA	Pearly-everlasting
Athyrium filix-femina (L.) Roth	ATFI	Lady-fern
Baccharis pilularis DC.	BAPI	Chaparral broom
Berberis spp.	BENE	Oregongrape
Blechnum spicant (L.) Roth	BLSP	Deer-fern
Carex spp.	CASP	Sedge
Cirsium spp.	CISP	Thistle
Corylus cornuta var. *californica* (A. DC.) Sharp	COCO	California hazel
Dicentra formosa (Andr.) Walp.	DIFO	Bleedingheart
Digitalis purpurea L.	DIPU	Foxglove
Echinocystis lobata (Michx.) T. & G.	ECLO	Wild cucumber
Epilobium spp.	EPAN	Fireweed
Equisetum spp.	EQSP	Horsetail
Erechtites arguta DC.	ERAR	Burnweed
Gaultheria shallon Pursh	GASH	Salal
Gramineae spp.	GRSP	Grass
Herbaceous	HEMI	Miscellaneous herbaceous
Holodiscus discolor (Pursh) Maxim.	HODI	Ocean-spray
Juncus spp.	JUSP	Rush
Lotus spp.	LOSP	Deervetch
Lupinus spp.	LUSP	Lupine
Lysichitum americanum Hulten & St. John	LYAM	Skunk cabbage
Menziesia ferruginea Smith	MEFE	False azalea
Montia spp.	MOSP	Candy flower
Osmaronia cerasiformis (T. & G.) Greene	OSCE	Indian plum
Oxalis oregana Nutt.	OXOR	Oxalis or wood-sorrel
Picea sitchensis (Bong.) Carr.	PISI	Sitka spruce
Polystichum munitum (Kaulf.) Presl	POMU	Sword-fern
Prunus spp.	PRSP	Cherry & plum
Pseudotsuga menziesii (Mirb.) Franco	PSME	Douglas-fir
Pteridium aquilinum (L.) Kuhn.	PTAQ	Bracken-fern
Quercus garryana Dougl. ex Hook.	QUGA	Oregon white oak
Rhamnus purshiana DC.	RHPU	Cascara buckthorn
Ribes bracteosum Dougl.	RIBR	Stink currant
Ribes sanguineum Pursh	RISA	Red flowering currant
Rosa gymnocarpa Nutt.	ROSA	Little wood rose
Rubus laciniatus Willd.	RULA	Evergreen blackberry
Rubus leucodermis Dougl.	RULE	Black raspberry or blackcap
Rubus parviflorus Nutt.	RUPA	Thimbleberry
Rubus procerus Muell.	RUPR	Himalayan blackberry
Rubus spectabilis Pursh	RUSP	Salmonberry
Rubus ursinus Cham. & Schlecht.	RUVI	Trailing blackberry
Salix spp.	SASP	Willow
Sambucus spp.	SAGL	Elder
Senecio spp.	SESP	Groundsel
Thuja plicata Donn ex D. Don	THPL	Western redcedar
Tsuga heterophylla (Raf.) Sarg.	TSHE	Western hemlock
Vaccinium membranaceum Dougl.	VAME	Thinleaf huckleberry
Vaccinium ovatum Pursh	VAOV	Evergreen huckleberry
Vaccinium parvifolium Smith	VAPA	Red huckleberry

Changes in Total Cover

Study averages for total and type of cover have been determined to identify broad cover trends and variations among study sites. These averages are based on data from all site-preparation treatments.

At the start of the study, vegetation cover averaged 51.9 percent; after site preparation on five-sixths of each area, total cover averaged 23.9 percent, but the reduction was very temporary (fig. 19, tables 2 and 19 to 25). By midsummer 1981, the first growing season after site preparation and planting, total cover on the study areas already averaged 63.5 percent. In the next 2 years, total cover increased to 85.3 percent and then more gradually to 99.6 percent by the end of the decade (fig. 20).

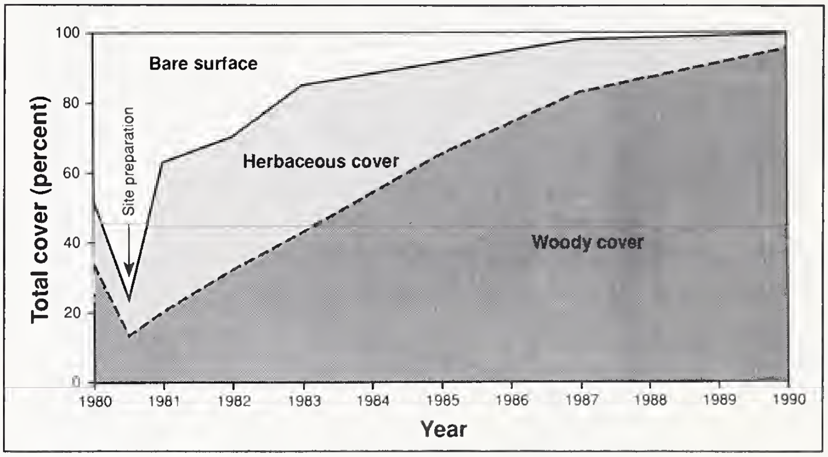

Figure 19—Postharvest development of cover on the study areas, average for all treatments and areas combined.

A higher percentage of total vegetative cover was removed by site preparation on Formader than on the other three sites, 71 vs. 54, 45 and 40 percent for LBJ, Camp 76, and Farmer, respectively (tables 2 and 19). After site preparation, more than 80 percent of the surface area on both Formader and Camp 76 had no vegetation; about two-thirds of the surface was bare on LBJ and Farmer. A year later, half of Formader was still bare but only about one-third on the other three areas. Bare surface continued to be reduced more rapidly on LBJ and Farmer than on the other two from 1981 to 1985; but by 1987, only nominal amounts were present except at Formader (tables 20 to 24). As defined for study purposes, bare surfaces included all those without vegetative cover including surfaces with mineral soil, duff, litter, slash, and solid wood.

About 60 percent of both woody and herbaceous cover was removed by site preparation, but herbaceous species provided a large share of the subsequent rapid increase in cover (fig. 19, tables 2 and 19 to 25). Herbaceous species increased from one-third of total cover in 1980 before site preparation to two-thirds of total cover in mid-1981, the first growing season after site preparation. The dominance of herbaceous vegetation was brief, however; for by 1983, slightly less than half of the dominant cover was comprised of woody species. Two years later, woody species were nearly 75 percent of the dominant cover. In the last half of the decade, dominance of herbaceous vegetation shrank to only 4.2 percent of the total dominant cover.

Table 19—Amount and composition of dominant vegetation on the study areas just after site preparation

Vegetation category	Formader Frequency	Formader Cover	LBJ Frequency	LBJ Cover	Camp 76 Frequency	Camp 76 Cover	Farmer Frequency	Farmer Cover	All Frequency	All Cover
					Percent					
Total vegetation:		17.2		27.3		18.5		32.6		23.9
Woody		8.4		21.6		7.5		16.1		13.4
Herbaceous		8.8		5.7		11.0		16.5		10.5
Bare surface		82.8		72.7		81.5		67.5		76.1
Species averaging 1-percent cover or more:										
Acer circinatum	6.1	2.6	0.8	.1	2.1	.7	2.9	.8	3.0	1.1
Herbaceous, miscellaneous	9.4	1.9	2.4	.3	16.9	2.6	14.3	2.8	10.8	1.9
Montia spp.	21.1	4.1	6.7	.9	15.0	2.1	27.1	4.2	17.5	2.8
Polystichum munitum	9.4	1.1	10.3	1.5	25.0	4.5	17.8	3.7	15.6	2.7
Rubus spectabilis	21.7	5.0	38.1	16.3	16.1	3.6	33.8	11.7	27.4	9.2
Senecio spp.	4.7	.5	4.6	.8	4.0	.3	20.0	2.9	8.3	1.1
Total of 6		15.2		19.9		13.8		26.1		18.8

Table 20—Amount and composition of dominant vegetation on the study areas in summer 1981, the first posttreatment growing season

Vegetation category	Formader Frequency	Formader Cover	LBJ Frequency	LBJ Cover	Camp 76 Frequency	Camp 76 Cover	Farmer Frequency	Farmer Cover	All Frequency	All Cover
					Percent					
Total vegetation:		48.7		69.0		67.5		68.8		63.5
Woody		15.9		34.6		13.0		18.2		20.4
Herbaceous		32.8		34.4		54.5		50.6		43.1
Bare surface		51.3		31.1		32.5		31.1		36.5
Species averaging 1-percent cover or more:										
Acer circinatum	7.2	3.0	0.8	.1	3.6	.5	2.9	.5	3.6	1.0
Epilobium spp.	4.4	.4	46.3	14.6	11.8	2.0	13.8	2.1	19.1	4.8
Gaultheria shallon	2.6	.3	22.4	4.7			.3	+[a]	6.3	1.2
Gramineae spp.	21.7	4.1	6.0	1.4	21.5	3.2	20.4	5.3	17.4	3.5
Herbaceous, miscellaneous	16.9	5.2	6.1	.9	33.3	5.6	36.4	7.6	23.2	4.8
Montia spp.	48.1	9.2	13.8	2.1	36.8	6.8	46.7	9.4	36.3	6.9
Polystichum munitum	11.7	1.6	11.8	2.0	36.5	8.5	23.5	3.7	20.9	3.9
Pseudotsuga menziesii	30.1	1.7	17.4	1.1	20.6	1.1	26.5	2.1	23.6	1.5
Pteridium aquilinum	9.0	1.9	8.2	3.7	.8	.1	10.1	2.3	7.0	2.0
Rubus spectabilis	35.1	8.6	53.8	26.6	23.2	6.3	41.0	12.6	38.3	13.5
Sambucus spp.	4.4	1.3	.3	.1	7.5	1.8	4.2	.8	4.1	1.0
Senecio spp.	49.0	9.9	37.5	9.6	70.3	26.6	67.8	19.8	56.1	16.5
Total of 12		47.2		66.9		62.5		66.2		60.6

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Table 21—Amount and composition of dominant vegetation on the study areas in summer 1982, the second posttreatment growing season

	Study area									
	Formader		LBJ		Camp 76		Farmer		All	
Vegetation category	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
					Percent					
Total vegetation:		60.1		78.2		63.1		79.8		70.3
Woody		27.1		43.5		23.1		36.0		32.4
Herbaceous		33.0		34.7		40.0		43.8		37.9
Bare surface		39.9		21.8		36.9		20.2		29.7
Species averaging 1-percent cover or more:										
Epilobium spp.	6.9	1.3	62.1	22.8	6.3	.7	23.5	3.6	24.7	7.1
Erechtites arguta	6.4	.6	2.9	.1	21.3	1.9	12.8	1.7	10.8	1.1
Gaultheria shallon	4.3	.5	30.6	6.0			.6	+[a]	8.9	1.6
Gramineae spp.	65.8	14.1	15.8	2.7	46.7	10.2	40.7	8.5	42.3	8.9
Herbaceous, miscellaneous	27.6	4.8	3.1	.3	57.6	10.6	51.8	10.7	35.0	6.6
Montia spp.	7.5	.5	3.6	.3	23.6	2.0	11.5	1.1	11.6	1.0
Polystichum munitum	12.1	1.5	10.0	1.3	33.3	7.8	20.0	3.4	18.9	3.5
Pseudotsuga menziesii	41.1	3.2	24.3	1.9	29.6	2.0	31.7	3.1	31.7	2.6
Pteridium aquilinum	15.7	5.1	12.4	4.9	1.7	.2	18.9	6.1	12.2	4.1
Rubus parviflorus	6.5	.3	4.7	.5	12.4	1.1	28.6	4.5	13.1	1.6
Rubus spectabilis	52.6	15.0	61.0	31.9	33.8	11.2	56.7	24.2	51.0	20.6
Rubus ursinus	17.4	3.7	15.6	2.3	7.4	.7	7.5	1.2	11.9	2.0
Sambucus spp.	8.3	2.3	.6	.1	15.0	3.0	6.7	1.4	7.6	1.7
Senecio spp.	18.6	1.8	5.1	.8	25.8	2.6	31.5	5.6	20.3	2.7
Total of 14		54.7		75.9		54.0		75.1		65.1

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Table 22—Amount and composition of dominant vegetation on the study areas in summer 1983, the third posttreatment growing season

	Study area									
	Formader		LBJ		Camp 76		Farmer		All	
Vegetation category	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
					Percent					
Total vegetation:		82.0		87.6		80.6		91.2		85.3
Woody		32.8		51.4		33.7		46.6		41.1
Herbaceous		49.2		36.2		46.9		44.6		44.2
Bare surface		17.9		12.4		19.4		8.8		14.6
Species averaging 1-percent cover or more:										
Digitalis purpurea	19.9	2.9	3.2	.3	9.0	1.2	18.3	3.5	12.6	2.0
Gaultheria shallon	3.6	.5	29.9	7.0			6.5	1.6	10.0	2.3
Gramineae spp.	65.6	18.9	18.9	5.1	52.2	13.3	23.6	5.2	40.1	10.6
Herbaceous, miscellaneous	51.1	9.8	20.8	2.5	56.8	11.7	44.0	10.4	43.2	8.6
Polystichum munitum	12.9	1.9	8.3	1.3	34.2	8.9	21.1	3.8	19.1	4.0
Pseudotsuga menziesii	47.1	6.6	33.9	5.1	41.5	5.5	39.7	7.3	40.6	6.1
Pteridium aquilinum	19.4	7.9	11.9	4.8	1.4	.2	21.1	8.4	13.5	5.3
Rubus parviflorus	5.3	.4	4.3	.7	23.5	2.9	27.1	6.0	15.0	2.5
Rubus spectabilis	55.4	17.9	60.3	34.8	47.5	15.0	56.9	27.4	55.0	23.8
Rubus ursinus	16.3	3.1	14.3	2.4	6.5	.9	6.5	.9	10.9	1.8
Sambucus spp.	6.5	2.4	.8	.1	12.8	3.0	6.1	1.4	6.6	1.7
Senecio spp.	32.6	5.6	58.2	21.9	34.0	5.4	39.7	11.7	41.1	11.2
Total of 12		77.9		86.0		68.0		87.6		79.9

Table 23—Amount and composition of dominant vegetation on the study areas in summer 1985, the fifth posttreatment growing season

	Study area									
	Formader		LBJ		Camp 76		Farmer		All	
Vegetation category	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
					Percent					
Total vegetation:		91.0		94.9		86.1		93.7		91.4
Woody		52.6		77.9		61.1		70.5		65.5
Herbaceous		38.4		17.0		25.0		23.2		25.9
Bare surface		9.0		5.0		13.9		6.4		8.6
Species averaging 1-percent cover or more:										
Acer circinatum	6.5	1.9	1.0	.3	3.6	1.1	3.8	.8	3.7	1.0
Alnus rubra	1.8	.8	1.1	.6	10.8	4.9	14.3	6.7	7.0	3.3
Anaphalis margaritacea	.8	.1	35.4	6.4	27.4	5.3	11.0	1.2	18.6	3.2
Digitalis purpurea	28.3	3.2	5.1	.4	12.2	1.9	20.4	3.4	16.5	2.2
Gaultheria shallon	5.1	.7	41.8	11.3			1.3	.2	12.0	3.0
Gramineae spp.	58.2	15.7	15.3	2.7	30.6	6.9	21.8	4.3	31.5	7.4
Herbaceous, miscellaneous	19.9	2.3	1.3	.1	10.1	1.4	9.2	1.0	10.1	1.2
Lotus spp.	30.3	4.2	13.6	1.4			4.3	.5	12.0	1.5
Polystichum munitum	13.8	2.5	7.2	.9	31.9	8.6	15.1	2.0	17.0	3.5
Pseudotsuga menziesii	60.8	20.1	57.8	21.2	57.1	18.8	61.3	22.6	59.2	20.7
Pteridium aquilinum	26.1	8.7	15.0	4.4	.7	.1	24.2	9.3	16.5	5.6
Rubus parviflorus	3.2	.2	5.7	.9	33.2	7.5	33.6	8.3	18.9	4.2
Rubus spectabilis	62.9	23.3	71.4	38.3	52.6	20.0	58.2	28.0	61.3	27.4
Rubus ursinus	22.5	3.5	26.5	3.8	7.4	1.0	8.6	1.3	16.3	2.4
Sambucus spp.	3.8	1.7	.8	.3	4.7	1.6	5.3	1.6	3.6	1.3
Total of 15		88.9		93.0		79.1		91.2		87.9

A. Formader

June 1980

B. Camp 76

July 1980

Figure 20 caption on page 42.

A. Formader (continued)

June 1981

August 1982

June 1984

B. Camp 76 (continued)

September 1980

July 1981

September 1982

Figure 20—Total vegetation cover increased rapidly after all site-preparation treatments. (A) Sprayed area (left) and spot-cleared area (right) at Formader. (B) Burned areas at Camp 76.

Table 24—Amount and composition of dominant vegetation on the study areas in summer 1987, the seventh posttreatment growing season

	Study area									
	Formader		LBJ		Camp 76		Farmer		All	
Vegetation category	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent									
Total vegetation:		95.9		98.8		98.2		98.3		97.9
Woody		67.9		88.8		83.6		84.0		81.1
Herbaceous		28.0		10.0		14.6		14.3		16.8
Bare surface		4.1		1.1		1.7		1.7		2.2
Species averaging 1-percent cover or more:										
Alnus rubra	3.2	1.7	2.9	1.6	33.9	16.9	24.2	16.0	16.0	9.0
Anaphalis margaritacea	.3	+[a]	21.3	4.0	21.8	3.8	6.1	.8	12.4	2.1
Digitalis purpurea	22.6	2.1	1.5	.1	11.9	1.3	12.8	2.1	12.2	1.4
Gaultheria shallon	4.9	.6	36.9	10.7			1.8	.2	10.9	2.9
Gramineae spp.	55.3	12.3	3.9	.5	16.3	3.0	12.6	2.7	22.0	4.6
Polystichum munitum	13.5	2.1	4.6	.6	18.5	4.5	7.4	.9	11.0	2.0
Pseudotsuga menziesii	66.1	39.4	65.1	43.3	58.2	31.2	64.3	38.0	63.4	38.0
Pteridium aquilinum	27.6	6.6	10.7	2.8	1.1	.1	21.4	6.6	15.2	4.0
Rubus parviflorus	1.9	.1	3.2	.8	36.5	9.9	21.9	6.1	15.9	4.2
Rubus spectabilis	58.8	19.9	54.7	28.0	42.5	15.7	39.3	19.1	48.8	20.7
Rubus ursinus	20.0	2.4	15.1	1.9	4.2	.4	5.8	.8	11.3	1.4
Sambucus spp.	3.6	1.5	.7	.3	5.3	1.8	5.0	1.7	3.6	1.3
Total of 12		88.7		94.6		88.6		95.0		91.6

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Till the end of the decade, herbaceous vegetation was a smaller proportion of total vegetation on LBJ than on the other three areas:

Year	**Formader**	**LBJ**	**Camp 76**	**Farmer**
		Proportion		
1980	0.35	0.20	0.50	0.41
1980a	.51	.21	.59	.51
1981	.67	.50	.81	.74
1982	.55	.44	.63	.55
1983	.60	.41	.58	.49
1985	.42	.18	.29	.25
1987	.29	.10	.15	.15
1990	.11	.02	.02	.03

Herbaceous vegetation constituted a higher proportion of total vegetation on Camp 76 than on other areas through 1982; after that, herbaceous vegetation was a higher proportion of the total on Formader, markedly higher from 1987 to 1990.

Table 25—Amount and composition of dominant vegetation on the study areas in summer 1990, the 10th posttreatment growing season

	Study area									
	Formader		LBJ		Camp 76		Farmer		All	
Vegetation category	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent									
Total vegetation:		99.4		99.8		100.0		99.5		99.6
Woody		88.7		97.9		98.4		96.8		95.4
Herbaceous		10.7		1.9		1.6		2.7		4.2
Bare surface		.6		.2		.1		.5		.4
Species averaging 1-percent cover or more:										
Acer macrophyllum					6.9	5.3			1.7	1.3
Alnus rubra	7.8	5.7	3.5	2.2	59.0	52.8	35.0	26.7	26.3	21.9
Gaultheria shallon	.8	.1	15.3	6.5			.1	+[a]	4.1	1.7
Gramineae spp.	14.9	4.9	.4	.1	.4	+	1.3	.4	4.2	1.3
Pseudotsuga menziesii	74.6	65.0	73.8	64.2	35.3	27.0	60.8	48.0	61.1	51.1
Pteridium aquilinum	7.6	3.1	3.1	.9	1.1	.1	2.6	.7	3.4	1.2
Rubus parviflorus			2.2	.7	4.3	2.2	10.3	4.9	4.2	1.9
Rubus spectabilis	26.7	13.5	28.5	18.9	11.9	8.5	18.3	11.4	21.4	13.1
Sambucus spp.	3.1	1.5	.6	.4	1.0	.6	5.0	2.6	2.4	1.3
Total of 9		93.8		93.9		96.5		94.7		94.8

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Although 56 species or groups were found as dominants in the vegetation examinations, fewer were dominant on any one area or at any one time (table 26). Nineteen to 24 species or groups were represented among dominant residual vegetation on individual study areas when the study started. The same number, 19 to 24, were represented a decade later, but the counts had switched slightly among areas. During the decade, the count of dominant species or groups per area was first reduced slightly by site preparation, 16 to 21, but then increased to as high as 28 to 35 in the fifth year. The highest number of dominant species present at one time in the whole study, 48, occurred in the second year after site preparation.

Though many species were found in a dominant position on one study area or another, a more limited number truly dominated the areas by their frequency and cover in the uppermost vegetation layer. Not counting the catchall group "miscellaneous herbaceous," 8 species or groups averaged 1 percent of the cover or more before site preparation, 5 immediately after site preparation, 11 to 14 between 1981 and 1987, and again only 9 in 1990 (tables 2 and 19 to 25). Nineteen species or groups actually were involved, for average coverage of some reached 1 percent during the decade, whereas for others it decreased to less than 1 percent (table 27).

Table 26—Species and species groups found at each location and examination

Year	Study area: Formader	LBJ	Camp 76	Farmer	All
	Number				
1980	19	20	19	24	30
1980a	16	19	19	21	29
1981	24	20	25	22	33
1982	30	33	33	33	48
1983	26	28	31	29	44
1985	28	32	31	35	45
1987	30	27	30	31	44
1990	21	24	19	23	33

Table 27—Dynamics of species that averaged more than 1-percent cover sometime during the study

Species	Year: 1980		1980a		1981		1982		1983		1985		1987		1990	
	Frequency and cover (percent)															
Acer circinatum	12.7	5.3	3.0	1.1	3.6	1.0	4.4	.9	3.5	.9	3.7	1.0	2.7	.9	1.9	.9
Acer macrophyllum	.5	.3	.3	.2	.6	.4	.7	.4	.8	.5	1.1	.7	1.4	.9	1.7	1.3
Alnus rubra	1.1	.4	.7	.4	.6	.2	.7	.4	1.6	.6	7.0	3.3	16.0	9.0	26.3	21.9
Anaphalis margaritacea	—	—	—	—	—	—	5.0	.4	.3	+[a]	18.6	3.2	12.4	2.1	.1	+
Digitalis purpurea	—	—	.2	+	.7	.1	6.2	.8	12.6	2.0	16.5	2.2	12.2	1.4	1.8	.4
Epilobium spp.	—	—	.7	.1	19.1	4.8	24.7	7.1	.6	+	1.6	.1	.3	+	—	—
Erechtites arguta	—	—	—	—	1.0	.1	10.8	1.1	6.9	.8	.6	.1	—	—	—	—
Gaultheria shallon	9.2	1.9	5.8	.9	6.3	1.2	8.9	1.6	10.0	2.3	12.0	3.0	10.9	2.9	4.1	1.7
Gramineae spp.	5.1	1.0	5.0	.8	17.4	3.5	42.3	8.9	40.1	10.6	31.5	7.4	22.0	4.6	4.2	1.3
Lotus spp.	—	—	—	—	—	—	5.6	.5	—	—	12.0	1.5	4.5	.3	.1	+
Montia spp.	29.2	6.1	17.5	2.8	36.3	6.9	11.6	1.0	1.1	.1	+	+	—	—	—	—
Polystichum munitum	30.3	6.1	15.6	2.7	20.9	3.9	18.9	3.5	19.1	4.0	17.0	3.5	11.0	2.0	3.0	.8
Pseudotsuga menziesii	—	—	—	—	23.6	1.5	31.7	2.6	40.6	6.1	59.2	20.7	63.4	38.0	61.1	51.1
Pteridium aquilinum	5.2	1.2	2.8	.7	7.0	2.0	12.2	4.1	13.5	5.3	16.5	5.6	15.2	4.0	3.4	1.2
Rubus parviflorus	3.9	1.0	2.9	.6	3.9	.7	13.1	1.6	15.0	2.5	18.9	4.2	15.9	4.2	4.2	1.9
Rubus spectabilis	57.8	22.4	27.4	9.2	38.3	13.5	51.0	20.6	55.0	23.8	61.3	27.4	48.8	20.7	21.4	13.1
Rubus ursinus	4.4	.9	1.7	.3	3.6	.5	11.9	2.0	10.9	1.8	16.3	2.4	11.3	1.4	4.0	.8
Sambucus spp.	3.9	.8	2.5	.4	4.1	1.0	7.6	1.7	6.6	1.7	3.6	1.3	3.6	1.3	2.4	1.3
Senecio spp.	8.8	.8	8.3	1.1	56.1	16.5	20.3	2.7	41.1	11.2	3.4	.4	4.1	.7	.9	.2

[a] Frequency or cover values less than 0.05 are indicated by a plus symbol.

Salmonberry was the predominant individual species in both frequency and cover before site preparation and through 1985 (fig. 21, table 27). As a group, groundsels shared prominence with salmonberry in 1981. In 1985, salmonberry was found on 61.3 percent of all transects and averaged 27.4 percent cover, a gain from 27.4 percent in frequency and 9.2 percent in cover immediately after site preparation. Salmonberry was still present in abundance in 1987 and 1990 but was declining in dominance as Douglas-fir attained a dominance frequency of 60 percent or more and expanded in cover from 20.7 to 51.1 percent. By 1990, red alder had attained second place in both frequency (26.3 percent) and cover (21.9 percent).

Figure 21—Salmonberry was the predominant species before site preparation and afterwards until 1985.

Camp 76

July 1980

July 1981

September 1982

Figure 22—Groundsels constituted nearly 1 percent of the total cover before site preparation, exceeded 16 percent the next year, but after the third season, decreased to low levels for the rest of the decade.

Groundsels and candy flower invaded the study areas in large numbers before site preparation (fig. 22), peaked in 1981, and then quickly declined. Prominent herbaceous invaders that started relatively slowly included pearly-everlasting, foxglove, fireweeds, burnweed, and deervetch.

In the decade since logging and site preparation, most herbaceous species and many woody species have appeared or increased in dominance, peaked, and have or are losing dominance to the expanding, taller conifers and hardwoods. Annuals and some woody species have not only lost dominance, they also are being crowded out.

Effects of Site Preparation

The broad successional trends initiated after logging and site preparation are clearly evident from the pooled vegetation data for locations. But vegetation changes attributable to individual site-preparation treatments also are evident and of particular interest. Differences in total cover, in the rate of recovery, and in relative composition of the cover resulted from different site preparation.

Total vegetative cover initially averaged between 46 and 57 percent for plots designated to receive each site-preparation treatment—a relatively minor range in cover (fig. 23, table 28). Total cover was reduced by every site preparation but to a substantially different degree (fig. 23, table 29). Five percent or less of total cover remained after any site preparation involving broadcast burning. Spot-clearing of vegetation in spring 1981 reduced total cover to 26 percent. For no site preparation and for aerial spraying, the same values are indicated for the first and second examinations because vegetation in these treatments was not remeasured when the others were measured for quick changes due to treatment.

By mid-1981, total cover in every site-preparation treatment averaged higher than before site preparation (fig. 23, tables 28 to 30). The increase was only 2 to 3 percent above the original level in the spray and spray-and-burn treatments, 12 to 25 percent in the others. In the burn treatments, the single season recovery represented a gain in cover of 54 to 58 percent; for spot-clear, 41 percent (fig. 24).

From 1981 on, total cover increased steadily to average nearly 100 percent by 1990 in every site preparation, but the rate of increase (or reduction of bare surface) differed among treatments (fig. 23, tables 31 to 35). By the second season, 1982, only 14- to 17-percent bare surface remained in the no-site-preparation and spot-clear treatments; the other four treatments had 30- to 44-percent bare surface remaining. In 1983, the same comparisons were 7 to 9 percent vs. 14 to 24 percent. From 1981 onward, slightly higher amounts of bare surface remained in areas sprayed with glyphosate than in any of the others.

The relative amounts of herbaceous and woody vegetation comprising the total cover also differed among treatments. From 1981 to 1987, woody vegetation was an appreciably higher proportion of total cover in the spot-clear and no-site-preparation treatments than in the other four (fig. 23, table 36).

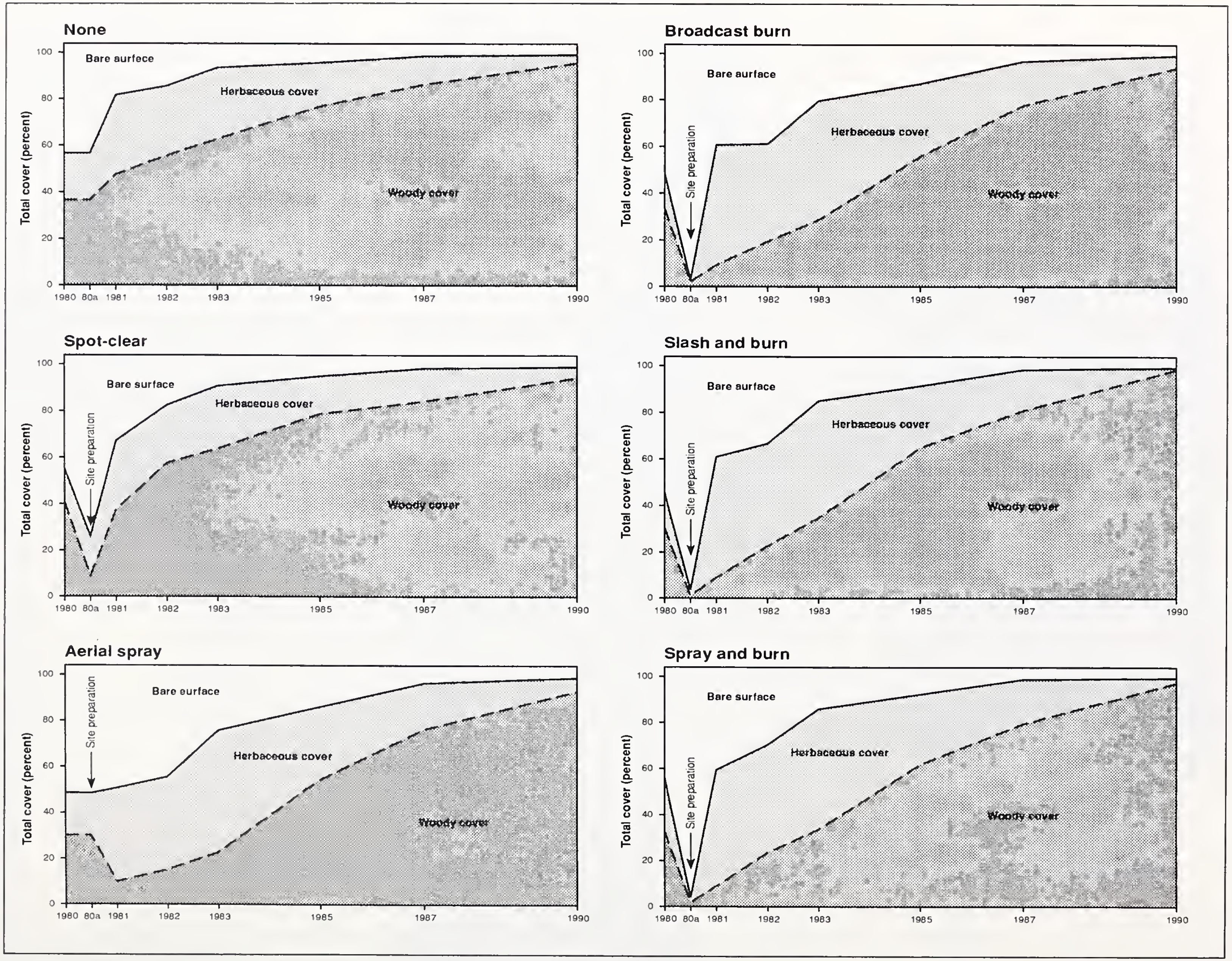

Figure 23—Changes in total, woody, and herbaceous vegetative cover from 1980 to 1990 in each site-preparation treatment.

Table 28—Amount and composition of dominant vegetation in 1980 before each site preparation

Vegetation category	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
Total vegetation:		56.6		55.2		48.8		48.6		45.6		56.3
Woody		35.6		40.7		30.3		33.6		30.5		33.0
Herbaceous		21.0		14.5		18.5		15.0		15.1		23.3
Bare surface		43.4		44.8		51.2		51.4		54.4		43.7
Species averaging 1-percent cover or more:												
Acer circinatum	9.6	4.2	12.5	5.0	6.9	2.0	21.0	9.9	13.3	6.2	13.1	4.6
Gaultheria shallon	9.4	2.0	4.2	.6	12.9	1.8	9.2	2.1	8.8	1.6	11.0	3.2
Gramineae spp.	4.0	.5	3.1	.5	5.2	.6	2.1	.5	5.0	.7	11.0	3.1
Herbaceous, miscellaneous	18.5	4.3	9.6	1.2	14.4	2.4	4.4	.5	11.7	1.9	17.1	4.2
Montia spp.	36.0	6.5	29.4	5.9	33.8	5.6	22.5	4.8	24.4	5.1	29.4	8.4
Polystichum munitum	28.5	5.7	25.0	5.0	36.0	6.9	35.2	7.8	27.9	5.3	29.4	6.1
Pteridium aquilinum	9.0	3.0	2.3	.6	4.8	1.1	5.4	.8	4.2	.8	5.8	1.0
Rubus parviflorus	.2	+[a]	3.8	.7	7.3	1.5	3.8	.8	1.9	.6	6.7	2.4
Rubus spectabilis	58.3	24.6	68.1	31.2	56.9	21.1	47.3	18.3	60.0	20.3	56.3	18.8
Total of 9		50.8		50.7		43.0		45.5		42.5		51.8

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Table 29—Amount and composition of dominant vegetation in 1980 just after each site preparation

Vegetation category	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
Total vegetation:		56.6		26.1		48.8		2.9		3.7		5.2
Woody		35.6		9.0		30.3		2.2		1.2		2.1
Herbaceous		21.0		17.1		18.5		.7		2.5		3.1
Bare surface		43.4		73.9		51.2		97.1		96.3		94.8
Species averaging 1-percent cover or more:												
Acer circinatum	9.6	4.2	1.3	.2	6.9	2.0					0.2	.1
Herbaceous, miscellaneous	18.5	4.3	26.7	3.3	14.4	2.4	0.2	.1	2.5	.5	2.3	.8
Montia spp.	36.0	6.5	34.8	4.7	33.8	5.6			.2	+[a]		
Polystichum munitum	28.5	5.7	20.4	2.3	36.0	6.9	3.1	.5	4.2	.7	1.5	.2
Rubus spectabilis	58.3	24.6	37.5	6.6	56.9	21.1	4.6	1.0	4.4	.9	2.7	.7
Senecio spp.	11.3	.9	21.0	3.3	13.5	1.4	.8	.1	3.1	.9		.2
Total of 6		46.2		20.4		39.4		1.7		3.0		1.8

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Table 30—Amount and composition of dominant vegetation in summer 1981, the first growing season after site preparation

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Vegetation category	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
Total vegetation:		81.7		67.3		50.8		60.5		61.0		59.6
Woody		47.5		37.5		9.9		9.3		9.0		9.1
Herbaceous		34.2		29.8		40.9		51.2		52.0		50.5
Bare surface		18.3		32.7		49.2		39.5		39.0		40.4
Species averaging 1-percent cover or more:												
Acer circinatum	7.5	3.8	6.0	.7	4.0	1.1	2.3	.2	1.0	.1	1.0	.1
Epilobium spp.	9.4	1.5	13.8	2.3	3.3	.3	25.2	5.1	29.2	10.0	33.5	9.5
Gaultheria shallon	7.5	1.8	4.4	.6	19.0	3.9	3.8	.8	1.7	.2	1.7	.2
Gramineae spp.	13.1	2.7	22.1	3.8	13.1	1.7	11.0	1.4	16.9	3.1	28.1	8.2
Herbaceous, miscellaneous	26.0	8.6	22.5	3.8	19.0	3.2	22.5	3.5	27.1	5.7	22.1	4.2
Montia spp.	26.0	4.5	28.8	4.4	62.5	15.3	32.9	4.1	23.8	3.0	44.0	10.0
Polystichum munitum	27.9	7.1	29.4	6.6	29.8	4.9	11.7	1.7	13.1	1.7	13.3	1.5
Pseudotsuga menziesii	14.6	.9	22.7	1.6	28.3	1.8	23.8	1.3	28.3	1.9	24.2	1.6
Pteridium aquilinum	9.6	5.1	4.0	1.1	1.9	.2	9.4	1.5	7.3	2.0	10.2	2.2
Rubus spectabilis	65.0	34.4	72.1	28.9	5.0	.6	25.8	5.8	35.6	6.2	26.0	5.1
Sambucus spp.	10.2	2.6	9.8	2.9	.8	.1	2.1	.2	1.3	.2	.4	.1
Senecio spp.	29.0	4.2	44.2	7.4	67.3	14.9	80.6	33.1	70.8	25.3	45.0	14.0
Total of 12		77.2		64.1		48.0		58.7		59.4		56.7

Before site preparation, the eight species or groups most common in the study were present in one or more plots of every treatment (table 28). The total number of species or groups present per treatment was close, ranging from 19 to 22, but not identical in species mix (table 37). Six additional species or groups—bleedingheart, false azalea, elders, groundsels, evergreen huckleberry, and red huckleberry—were present in every treatment in quantities averaging less than 1-percent cover. Red alder, oxalis, cherry or plum, and trailing blackberry were present in three or more treatments. Over all, 30 separate species or groups, including two uncommon ones, were represented in the six site-preparation treatments when the study started.

Before site preparation, salmonberry was the predominant species by a wide margin; it occurred on 47 percent or more of the transects per treatment and constituted 18- to 31-percent cover. Sword-fern and candy flower also were widespread; each occurred on at least 23 percent of transects per treatment and constituted 5-percent or more cover in every treatment.

A

July 1980

June 1984

October 1985

June 1987

B

July 1980

April 1981

Caption for figure 24 is on page 53.

B (continued)

July 1981

August 1982

June 1984

October 1985

November 1986

June 1987

C

July 1980

October 1980

July 1981

September 1982

October 1985

June 1987

Figure 24—Vegetation dynamics after site-preparation treatments at LBJ: (A) Aerial spraying (left) and no site preparation (right). The common border between treatments runs from the left foreground to a thin snag in the left background. (B) Rapid recovery of salmonberry after spot-clearing. Two stumps identify the same location through time. (C) Changes brought about during and after broadcast burning. A stake, small stump, and log serve as markers.

Table 31—Amount and composition of dominant vegetation in summer 1982, the second growing season after site preparation

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Vegetation category	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
Total vegetation:		85.6		82.6		55.7		61.1		66.7		70.2
Woody		55.6		57.7		15.2		19.5		22.8		23.6
Herbaceous		30.0		24.9		40.5		41.6		43.9		46.6
Bare surface		14.4		17.4		44.3		38.9		33.3		29.9
Species averaging 1-percent cover or more:												
Epilobium spp.	7.5	1.0	17.1	3.5	21.5	5.0	34.4	10.6	32.9	11.1	34.8	11.5
Erechtites arguta	4.8	.4	2.9	.4	19.4	2.9	19.8	1.3	12.5	1.0	5.6	.3
Gaultheria shallon	6.7	1.9	6.0	.7	21.0	4.7	7.1	1.2	4.4	.5	7.9	.7
Gramineae spp.	25.2	5.8	30.2	5.7	47.9	10.9	45.4	8.2	49.6	10.6	55.2	12.2
Herbaceous, miscellaneous	33.1	7.1	23.8	3.7	34.4	4.6	38.1	6.6	38.3	8.7	42.5	9.1
Montia spp.	4.8	.3	4.6	.3	32.9	3.5	13.5	.9	6.0	.5	7.5	.4
Polystichum munitum	25.8	6.5	23.8	5.8	18.3	2.3	16.5	2.5	15.2	2.1	13.5	1.8
Pseudotsuga menziesii	17.7	1.3	22.7	1.6	33.5	2.5	37.3	3.3	36.7	3.1	42.1	3.6
Pteridium aquilinum	12.5	6.1	7.3	2.1	4.2	.8	18.1	5.8	10.2	4.4	20.6	5.4
Rubus parviflorus	7.9	.8	14.8	3.0	6.9	.4	18.8	1.6	16.5	1.7	13.5	2.2
Rubus spectabilis	71.7	39.8	80.0	45.4	15.2	1.6	37.9	10.6	59.0	15.0	42.3	11.0
Rubus ursinus	5.8	.5	4.2	.6	17.7	3.6	8.5	1.0	6.5	1.1	29.0	5.0
Sambucus spp.	10.4	3.5	14.6	4.5	3.3	.4	7.1	.7	5.6	.6	4.8	.5
Senecio spp.	9.6	1.0	9.4	1.1	43.3	8.2	22.3	2.1	16.9	1.7	20.2	2.0
Total of 14		76.0		78.4		51.4		56.4		62.1		65.7

Table 32—Amount and composition of dominant vegetation in summer 1983, the third growing season after site preparation

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Vegetation category	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
Total vegetation:		93.5		90.8		75.8		79.7		85.8		86.5
Woody		62.6		64.0		22.9		28.6		34.8		33.8
Herbaceous		30.9		26.8		52.9		51.1		51.0		52.7
Bare surface		6.5		9.2		24.2		20.3		14.2		13.5
Species averaging 1-percent cover or more:												
Digitalis purpurea	13.1	2.3	21.3	4.5	14.0	1.5	8.3	1.1	10.4	1.4	8.5	.9
Gaultheria shallon	8.8	3.2	7.7	1.6	22.5	5.4	7.3	1.1	5.2	.7	8.5	1.5
Gramineae spp.	23.5	8.0	21.9	4.7	46.5	13.0	44.0	11.1	48.8	11.8	55.8	15.1
Herbaceous, miscellaneous	23.8	4.5	19.2	3.1	47.9	11.5	51.5	9.0	55.6	10.2	61.3	13.4
Polystichum munitum	21.3	6.3	25.2	6.4	18.8	3.4	18.3	3.1	14.6	2.2	16.7	2.4
Pseudotsuga menziesii	20.0	2.7	27.9	3.9	43.5	6.6	48.8	7.7	46.9	7.5	56.3	8.5
Pteridium aquilinum	9.6	4.9	7.3	2.8	4.4	.8	24.4	10.0	12.3	5.6	22.9	7.9
Rubus parviflorus	5.8	1.4	14.4	4.0	10.6	1.0	21.9	2.5	19.0	3.0	18.5	3.2
Rubus spectabilis	71.9	42.7	81.0	47.1	21.9	3.0	40.4	13.3	63.8	20.6	51.3	16.0
Rubus ursinus	4.6	.6	4.6	.9	20.2	4.1	9.0	1.2	6.3	.9	20.8	3.2
Sambucus spp.	9.4	3.1	9.8	4.1	4.2	.6	6.3	1.1	5.2	.8	4.6	.7
Senecio spp.	15.2	3.0	21.0	4.1	62.7	18.5	49.2	14.7	51.0	15.2	47.7	11.4
Total of 12		82.7		87.2		69.4		75.9		79.9		84.2

Table 33—Amount and composition of dominant vegetation in summer 1985, the fifth growing season after site preparation

Vegetation category	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
Total vegetation:		95.6		95.0		86.2		87.1		91.9		92.8
Woody		76.9		78.9		54.5		55.7		65.3		61.8
Herbaceous		18.7		16.1		31.7		31.4		26.6		31.0
Bare surface		4.4		5.0		13.8		12.9		8.2		7.2
Species averaging 1-percent cover or more:												
Acer circinatum	6.5	2.4	5.4	1.5	2.7	.6	4.8	1.0	1.9	.5	1.0	.3
Alnus rubra	6.7	3.9	4.2	1.5	3.5	.8	7.7	3.1	12.3	7.3	7.7	3.0
Anaphalis margaritacea	2.5	.3	6.7	1.2	19.2	3.0	24.8	4.3	29.2	5.6	29.6	5.0
Digitalis purpurea	9.6	1.1	11.9	1.1	43.1	7.8	11.0	1.0	11.7	1.3	11.9	1.0
Gaultheria shallon	9.4	2.7	6.3	1.2	25.2	7.1	10.8	2.3	9.0	1.7	11.7	3.2
Gramineae spp.	23.1	6.8	16.9	3.9	47.9	11.8	35.8	8.1	29.2	5.7	35.8	8.0
Herbaceous, miscellaneous	7.1	.8	4.6	.4	21.0	2.9	7.3	.5	7.7	.8	12.9	1.7
Lotus spp.	.4	+[a]	1.3	.1	6.5	.6	21.0	2.8	19.8	3.0	23.3	2.7
Polystichum munitum	20.0	6.4	20.0	5.7	20.8	3.1	16.5	2.3	11.3	1.5	13.5	1.9
Pseudotsuga menziesii	38.8	10.2	42.5	11.9	68.8	24.6	68.8	25.9	65.4	24.3	71.3	27.0
Pteridium aquilinum	9.2	2.8	9.4	2.7	6.0	1.1	31.7	11.7	15.6	5.8	27.1	9.7
Rubus parviflorus	10.0	2.4	16.0	5.3	20.6	3.7	22.9	4.0	20.0	4.3	24.0	5.6
Rubus spectabilis	77.3	46.3	83.3	51.5	40.8	8.1	48.8	16.2	65.2	24.0	52.3	18.2
Rubus ursinus	8.3	1.0	7.9	.9	32.1	5.7	13.1	1.6	10.6	1.7	25.4	3.3
Sambucus spp.	5.6	2.1	6.3	2.9	3.3	.8	2.5	.5	2.7	.9	1.5	.5
Total of 15		89.2		91.8		81.7		85.3		88.4		91.1

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Table 34—Amount and composition of dominant vegetation in summer 1987, the seventh growing season after site preparation

Vegetation category	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
Total vegetation:		98.5		98.3		96.4		96.7		98.4		98.8
Woody		86.2		85.1		76.3		77.6		81.7		79.6
Herbaceous		12.3		13.2		20.1		19.1		16.7		19.2
Bare surface		1.5		1.6		3.6		3.3		1.6		1.2
Species averaging 1-percent cover or more:												
Alnus rubra	10.6	7.1	10.0	6.2	12.7	6.2	19.4	9.0	24.0	15.2	19.6	10.4
Anaphalis margaritacea	1.5	.3	5.6	.8	8.5	1.4	20.2	3.5	18.3	3.8	20.0	3.1
Digitalis purpurea	5.8	.5	10.4	1.3	26.3	3.9	9.4	.8	11.7	1.2	9.8	.8
Gaultheria shallon	9.0	3.1	7.3	2.0	20.6	5.0	10.2	2.6	6.5	1.5	11.9	3.1
Gramineae spp.	19.0	5.0	15.8	3.1	27.9	6.3	23.1	4.7	20.0	4.1	26.3	4.7
Polystichum munitum	13.5	4.3	16.7	3.4	15.8	2.0	7.1	.8	6.9	.8	5.8	.8
Pseudotsuga menziesii	44.0	20.5	50.8	24.0	71.0	44.3	71.9	47.7	68.1	45.0	74.8	46.2
Pteridium aquilinum	3.8	.6	8.3	2.6	8.8	1.9	26.9	7.2	14.0	4.2	29.6	7.8
Rubus parviflorus	8.5	2.4	16.9	6.3	21.7	5.1	16.0	3.1	13.3	2.8	19.0	5.8
Rubus spectabilis	68.8	41.2	74.0	38.6	34.0	7.3	35.4	12.6	45.8	14.9	35.0	9.6
Rubus ursinus	5.2	.4	6.7	.8	24.6	3.5	9.6	.9	5.4	.7	16.3	1.9
Sambucus spp.	5.0	2.4	7.3	2.7	2.5	.9	1.9	.4	2.1	.6	3.1	.9
Total of 12		87.8		91.8		87.8		93.3		94.8		95.1

Table 35—Amount and composition of dominant vegetation in summer 1990, the 10th growing season after site preparation

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Vegetation category	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
						Percent						
Total vegetation:		99.7		99.5		99.2		99.7		99.8		99.9
Woody		96.0		94.3		92.8		93.8		98.4		97.2
Herbaceous		3.7		5.2		6.4		5.9		1.4		2.7
Bare surface		.3		.5		.8		.3		.1		.1
Species averaging 1-percent cover or more:												
Acer macrophyllum	6.9	4.9	1.9	1.7	1.5	1.3					.2	.1
Alnus rubra	17.3	14.4	16.3	13.9	21.3	17.0	32.9	26.0	39.4	31.4	30.8	28.4
Gaultheria shallon	6.5	2.1	2.9	1.0	4.4	1.9	4.0	1.8	1.0	.4	5.6	2.6
Gramineae spp.	4.2	1.1	6.3	1.7	5.8	2.0	5.6	2.0	1.9	.5	1.7	.7
Pseudotsuga menziesii	44.2	34.2	51.5	40.7	71.7	61.8	68.8	55.6	64.8	56.6	65.8	57.7
Pteridium aquilinum	1.5	.3	3.1	1.0	4.2	2.0	6.3	2.3	1.0	.2	4.2	1.4
Rubus parviflorus	2.7	1.0	10.0	5.2	6.7	2.9	1.0	.3	1.5	.6	3.3	1.7
Rubus spectabilis	43.5	31.0	42.5	25.9	9.8	4.1	15.0	8.1	10.8	6.9	6.5	2.6
Sambucus spp.	4.8	2.8	4.6	2.3	1.3	.6	.6	.3	.8	.4	2.3	1.1
Total of 9		91.8		93.4		93.6		96.4		97.0		96.3

Table 36—Woody vegetation as a proportion of total vegetation by site preparation and year

	Site preparation					
Year	None	Spot-clear	Spray	Burn	Slash and burn	Spray and burn
			Proportion			
1980	0.63	0.74	0.62	0.69	0.67	0.59
1980a	.63	.34	.62	.76	.32	.40
1981	.58	.56	.19	.15	.15	.15
1982	.65	.70	.27	.32	.34	.34
1983	.67	.70	.30	.36	.41	.39
1985	.80	.83	.63	.64	.71	.67
1987	.88	.87	.79	.80	.83	.81
1990	.96	.95	.94	.94	.99	.97

Table 37—Species present in 1 or more plots of each site preparation by year

Species or group	Year 1980	1980a	1981	1982	1983	1985	1987	1990
	Site preparation[a]							
Abies grandis	4							
Acer circinatum	1,2,3,4,5,6	1,2,3, 6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6
Acer macrophyllum	1,2	1	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3, 6
Adiantum pedatum	1	1	1	1	1		1	
Alnus rubra	1,2,3, 5,6	1,2,3, 6	1,2,3, 6	1,2,3, 5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6
Amelanchier florida					1			
Anaphalis margaritacea				1,2,3,4,5,6	1,2,3	1,2,3,4,5,6	1,2,3,4,5,6	2, 5,6
Athyrium filix-femina				2, 4	2	1,2,3, 5,6	1,2,3, 5,6	1,2
Baccharis pilularis				5			5	
Berberis spp.			3	2,3	2,3	3, 5	3, 5	
Blechnum spicant				5	1, 5	1,2,3,4,5	2,3	2
Carex spp.				4	1, 6	5		
Cirsium spp.		2	1,2, 4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1
Corylus cornuta var. *California*	4		1, 3,4	1, 3,4	1,2,3,4	1,2,3,4, 6	1,2,3,4,5,6	1,2,3
Dicentra formosa	1,2,3,4,5,6	1,2,3,4,5	2,3,4,5,6	2,3,4,5,6	2, 5		2	
Digitalis purpurea		2	1,2, 4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6
Echinocystis lobata				1,2,3,4,5	1,2,3,4,5	3,4	1,2,3,4,5	4,5
Epilobium spp.		2	1,2,3,4,5,6	1,2,3,4,5,6	1, 3,4,5,6	2,3,4,5,6	1, 3,4,5,6	
Equisetum spp.				6		1	1,2, 5,6	
Erechtites arguta			1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	3,4, 6		
Gaultheria shallon	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6
Gramineae spp.	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5.6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6
Herbaceous, miscellaneous	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6
Holodiscus discolor	1, 5	1		5	5	1, 3,4,5,6	1, 3,4,5,6	5
Juncus spp.				1,2, 5	1,2, 5	2, 5,6		
Lotus spp.				3,4,5,6		1,2,3,4,5,6	2,3,4,5,6	2, 4
Lupinus spp.			3, 6	2,3,4		2,3,4,5,6	3,4, 6	
Lysichitum americanum	4,5	5	2, 5	5	5	5,6		
Menziesia ferruginea	1,2,3,4,5,6	1,2,3	1,2	1,2	1,2	1,2,3	1,2,3	1,2,3
Montia spp.	1,2,3,4,5,6	1,2,3, 5	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3	3		
Osmaronia cerasiformis				4,5,6	3			
Oxalis oregana	1,2,3, 5	1,2,3	1,2, 5	1,2,3, 5,6			1, 5	
Picea sitchensis	3	3		1	3	1,2,3, 5	1,2,3,4,5	1,2,3,4,5
Polystichum munitum	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6
Prunus spp.	1, 3,4	1, 3	1,2, 4	3,4,5,6	4,5,6	1,2, 4,5,6	2, 4,5,6	1,2
Pseudotsuga menziesii			1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6
Pteridium aquilinum	1,2,3,4,5,6	1,2,3, 5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6
Quercus garryana			5					
Rhamnus purshiana	6	6			3,4	2, 4,5,6	2,3,4,5,6	1,2,3,4,5,6
Ribes bracteosum	2,3	3,4	1,2, 4	1,2,3,4, 6	1,2,3,4,5,6	1,2,3,4,5,6	2,3	2,3, 6
Ribes sanguineum				1, 5		4, 6	2, 4	
Rosa gymnocarpa	2, 6		3,4,5	2,3,4,5	3,4,5	3,4,5	3,4,5	
Rubus laciniatus				1	4, 6	1, 5	2	5
Rubus leucodermis				1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	
Rubus parviflorus	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6
Rubus procerus							2, 4,5,6	3, 6
Rubus spectabilis	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6
Rubus ursinus	1, 3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6
Salix spp.				1	3			
Sambucus spp.	1,2,3,4,5,6	1,2,3	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6
Senecio spp.	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6
Thuja plicata						6		
Tsuga heterophylla						2, 5	5	2, 4,5,6
Vaccinium membranaceum	4							
Vaccinium ovatum	1,2,3,4,5,6	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4, 6
Vaccinium parvifolium	1,2,3,4,5,6	1,2,3,4	1,2,3,4	1,2,3,4,5	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5
Total number	30	29	33	48	44	45	44	33

[a] Site preparations numbered 1 to 6 are none, spot-clear, spray, burn, slash and burn, and spray and burn, respectively.

Just after site preparation, five species or groups averaged 1-percent cover or more (table 29). Four of these also were present initially, and groundsels had increased to the 1-percent-cover level. Salal, grass, thimbleberry, and trailing blackberry were present in all treatments but at levels averaging less than 1-percent cover (table 37). From the initial vegetation examination to just after site preparation, three new species appeared in the transects—thistles, foxglove, and fireweeds—and four were at least temporarily not represented—grand fir, California hazel, little wood rose, and thinleaf huckleberry—leaving a net of 29 different species or groups present among all treatments, 21 to 22 in the unburned areas, 11 to 12 in the burned areas.

Among the five species or groups present in quantity just after site preparation, only one was present in burned areas at levels as high as 1-percent cover—salmonberry in the burn treatment (table 29). Two less abundant species also had 1-percent cover or more in a burn treatment—grass and thimbleberry. False azalea was eliminated in burned areas; and such well-represented species as vine maple, candy flower, bracken-fern, elders, and evergreen huckleberry were nearly eliminated temporarily. Burning also greatly reduced the frequency and cover of everything else that had been present initially.

Three species—bigleaf maple, stink currant, and little wood rose—were temporarily eliminated by spot-clearing, but four invaders immediately gained dominant positions—thistles, foxglove, fireweeds, and trailing blackberry.

By mid-1981, the first growing season after site preparation, 11 species or groups averaged 1-percent cover—one-third more than initially and twice as many as just after site preparation (table 30). Every species with 1-percent or more cover in either previous examination was there in quantity except thimbleberry. Douglas-fir and elders were new additions with 1-percent or more average cover; burnweed, thimbleberry, and trailing blackberry also were found in every treatment but averaged less than 1-percent cover. Twelve additional species or groups were present in at least half the treatments. Total species present numbered 20 to 23 in burned areas, 24 in the glyphosate sprayings, and 27 in spot-clearing and no-site-preparation areas; in the aggregate, 33 separate species were dominant among all treatments (table 37).

The 1981 examination revealed the first appearance of Douglas-fir, which had just been planted in the spring. Invading annuals that became common to most treatments included thistles, foxglove, fireweeds, and burnweed (table 37). California hazel and little wood rose reappeared among the woody species present in one or more treatments.

Between 1982 and 1987, 48, 44, 45, and 44 species or groups per examination were found among all treatments, ranging from 23 to 36 per individual treatment (table 37). Eleven to 14 species averaged more than 1-percent cover at each examination with several herbaceous species or groups (fireweeds, burnweed, candy flower, and groundsels) dropping below this level and three others (pearly-everlasting, foxglove, and deervetch) increasing to more than 1-percent cover during this period (tables 31 to 34). By and large, most invader species occurred as dominants in all treatments; but their frequency and cover varied, influenced to some extent by the amount of surface already occupied by woody species and thus not available for colonization.

By 1990, dominance was still shared by 33 species (21 to 28 per treatment), but only 9 averaged more than 1-percent cover (table 35, 37). The only herbaceous group still present with cover averaging more than 1 percent was a mix of grasses. Frequency and cover of Douglas-fir were highest in the spray treatment (71.7 and 61.8 percent, respectively), not far behind in the three burn treatments, and substantially less in the spot-clear and no-preparation treatments. Cover of salmonberry averaged 5.4 percent in burn or spray treatments, only one-fifth as much as in the spot-clear and no-site-preparation treatments.

Species Diversity

Through felling and harvesting of the overstory, site dominance was forceably wrested from a few species of conifers and hardwoods and made more available to residual and invading species. Overstory removal triggered a major early succession trend common to all study sites. To various extents, site preparation further diminished the residual vegetation present, thereby providing more bare area (fig. 23) and more opportunities for surviving residual species and invaders to colonize and expand. Trees were planted to supplement the natural successional processes and make more certain that a desired crop species would be a major component of the developing vegetation complex.

Drastic disturbance of the original stand fostered species diversity, at least for an interim period, but site preparation seems to have been only a minor influencing factor. Due to site preparation, large differences developed in species frequency and cover but relatively minor differences in the total number and mix of species present in the dominant vegetation (tables 38 and 39). Nineteen to 22 species or species groups were found per treatment initially, about 12 immediately after slash burning. At peak numbers, 32 to 36 species or species groups were found per treatment. This peak occurred in 1982 on unprepared areas, 1985 to 1987 for all site-prepared areas. Gain over original number of species per treatment ranged from 11 to 16. At the end of the decade, 0 to 8 more species were present per treatment than originally, and number of species was highest in spot-cleared areas.

Table 38—Number of species and species groups found dominant in each site preparation at each examination

	Site preparation					
Year	None	Spot-clear	Spray	Burn	Slash and burn	Spray and burn
	Number of species and species groups					
1980	22	20	21	21	20	19
1980a	22	21	21	11	12	12
1981	27	27	24	23	22	20
1982	34	33	33	31	34	27
1983	32	30	32	26	28	23
1985	31	33	35	32	36	33
1987	30	35	34	31	35	29
1990	24	28	23	21	22	21

Table 39—Dominance status of species in each site-preparation treatment during the decade

Site preparation	Dominant only in 1980 No.	Dominant only in 1980 Species	Dominant in 1980 but gone by 1990 No.	Dominant in 1980 but gone by 1990 Species	Gaining and losing dominance during decade No.	Gaining and losing dominance during decade Species	Gaining dominance since 1980 No.	Gaining dominance since 1980 Species	Dominant[a] throughout decade No.	Dominant[a] throughout decade Species	Never dominant in treatment No.	Never dominant in treatment Species
None	1	DIFO	4	ADPE HODI MOSP OXOR	15	AMFL ANMA BESP CASP ECLO EPSP EQSP ERAR JUSP LOSP RIBR RISA RULA RULE SASP	7	ATFI CISP COCO DIPU PISI PSME RHPU	16	ACCI ACMA ALRU GASH GRSP MEFE POMU PRSP PTAQ RUPA RUSP RUVI SAGL SESP VAOV VAPA	12	ABGR BAPI BENE LUSP LYAM OSCE QUGA ROSA RUPR THPL TSHE VAME
Spot-clear	0	—	4	DIFO MOSP OXOR ROSA	13	BENE CISP ECLO EPSP EQSP ERAR JUSP LUSP LYAM RISA RULA RULE RUPR	12	ANMA AFTI BLSP COCO DIPU LOSP PISI PRSP PSME RHPU RUVI TSHE	15	ACCI ACMA ALRU GASH GRSP MEFE POMU PTAQ RIBR RUPA RUSP SAGL SESP VAOV VAPA	11	ABGR ADPE AMFL BAPI CASP HODI OSCE QUGA SASP THPL VAME
Spray	0	—	4	DIFO MOSP OXOR PRSP	15	ANMA AFTI BENE BLSP CISP ECLO EPSP ERAR HODI LOSP LUSP OSCE ROSA RULE SASP	6	ACMA COCO DIPU PSME RHPU RUPR	16	ACCI ALRU GASH GRSP MEFE PISI POMU PTAQ RIBR RUPA RUSP RUVI SAGL SESP VAOV VAPA	14	ABGR ADPE AMFL BAPI CASP EQSP JUSP LYAM QUGA RISA RULA THPL TSHE VAME
Burn	4	ABGR LYAM MEFE VAME	4	COCO DIFO MOSP PRSP	16	ANMA ATFI BLSP CASP CISP EPSP ERAR HODI LUSP OSCE RIBR RISA ROSA RULA RULE RUPR	8	ALRU DIPU ECLO LOSP PISI PSME RHPU TSHE	12	ACCI GASH GRSP PTAQ POMU RUPA RUSP RUVI SAGL SESP VAOV VAPA	11	ACMA ADPE AMFL BAPI BENE EQSP JUSP OXOR QUGA SASP THPL
Slash and burn	1	MEFE	5	DIFO LYAM MOSP OXOR VAOV	22	AFTI BAPI BENE BLSP CASP CISP COCO EPSP EQSP ERAR JUSP LOSP LUSP OSCE PRSP QUGA RIBR RISA ROSA RULA RULE RUPR	7	AMMA DIPU ECLO PISI PSME RHPU TSHE	13	ACCI ALRU GASH GRSP HODI POMU PTAQ RUPA RUSP RUVI SAGL SESP VAPA	7	ABGR ACMA ADPE AMFL SASP THPL VAME
Spray and burn	2	MEFE ROSA	3	DIFO MOSP VAPA	19	AFTI CASP CISP COCO EPSP EQSP ERAR HODI JUSP LOSP LUSP LYAM OSCE OXOR PRSP RISA RULA RULE THPL	6	ANMA DIPU PSME RIBR RUPR TSHE	13	ACCI ALRU GASH GRSP POMU PTAQ RHPU RUPA RUSP RUVI SAGL SESP VAOV	12	ABGR ACMA ADPE AMFL BAPI BENE BLSP ECLO PISI QUGA SASP VAME

[a] Found in most or all examinations.

Comparisons of the species found dominant originally, and dominance changes through the decade do not reveal any large compositional difference due to treatment. Similar numbers, but not exactly the same species, were present initially on treatment areas. Likewise, similar numbers, but not exactly the same species per treatment, gained, lost, or retained dominance during the decade (table 39). Even species of common occurrence were not represented in every treatment, let alone those of infrequent dominance. Only a few of the changes in species composition appear related to treatment rather than to happenstance.

Several of the original species were not found again as dominants in a particular treatment, but only grand fir and thinleaf huckleberry were not found again in any treatment (table 39). Only one species, false azalea, definitely lost dominance because of site preparation by burning. Cascara buckthorn and red alder gained more widespread dominance because of disturbance.

Response of Individual Species

A description of vegetation responses to different site preparation necessarily involves generalizations pertinent to groups of species. Each species, however, reveals something about its individual characteristics as it responds to the conditions produced by different site preparation. Such information is presented in this section with a look at the decade-long response of individual species. All species and species groups are included except the seven already identified as of infrequent or incidental occurrence and the catchall group, miscellaneous herbaceous.

Acer circinatum was dominant at the first examination in plots destined for every site preparation (frequency 6.9 to 21.0 percent, cover 2.0 to 9.9 percent)—an important component of postharvest residual cover (table 40). Even with no site preparation, vine maple gradually lost dominance during the decade—frequency reduced from 9.6 to 4.6 percent, cover from 4.2 to 3.0 percent. Broadcast burning and spot-clearing caused an immediate reduction in frequency and cover to low levels; loss of vine maple dominance occurred more gradually after glyphosate spraying but also reached a low level. Although there were some minor gains in mid-decade, frequency of vine maple declined in every treatment; its cover is much lower after 10 years than it was originally, particularly in the burn or spray treatments.

Average height of vine maple ranged from 115 to 225 centimeters in different treatments at the start of the study, with maximum heights greater than 1000 centimeters not uncommon. Average height increased gradually during the decade, ranging from 178 to 386 centimeters among treatments by the 10th year. Older residual stems either died back or faded away, however, leaving maximum stem heights of 330 to 540 centimeters. The greatest average height and tallest trees were on unprepared sites.

Because vine maple is commonly thought of as a significant and threatening competitor when establishing tree plantations, its declining role among associated species in this study came as a surprise. At least part of the decline was due to animal influences. Big-game animals browsed this species heavily, and mountain beaver topped and kept many of the smaller stems nearly branchless from repeated foraging.

Table 40—Frequency, cover, and height of *Acer circinatum* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980	9.6	4.2	12.5	5.0	6.9	2.0	21.0	9.9	13.3	6.2	13.1	4.6
1980a	9.6	4.2	1.3	.2	6.9	2.0					.2	.1
1981	7.5	3.8	6.0	.7	4.0	1.1	2.3	.2	1.0	.1	1.0	.1
1982	7.9	2.6	6.0	.9	4.2	.6	4.2	.5	1.9	.3	2.5	.4
1983	6.5	2.7	6.0	.9	2.1	.3	3.5	.7	1.5	.3	1.7	.3
1985	6.5	2.4	5.4	1.5	2.7	.6	4.8	1.0	1.9	.5	1.0	.3
1987	5.0	2.6	4.4	1.2	2.1	.6	2.5	.5	1.0	.3	1.0	.4
1990	4.6	3.0	2.5	.9	1.3	.4	1.7	.6	.4	.1	1.0	.5
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980	225	16-999[a]	155	8-700	144	24-500	170	6-999	185	11-999	115	9-999
1980a	255	16-999	59	38-90	144	24-500					21	21
1981	321	21-999	55	22-150	99	15-300	46	19-103	32	11-55	31	13-60
1982	271	11-999	80	20-200	77	2-280	72	9-260	50	13-94	56	16-130
1983	225	40-630	83	12-200	76	21-220	85	14-210	71	20-133	58	10-165
1985	299	25-800	132	30-260	111	20-273	109	18-240	111	35-175	175	102-300
1987	367	50-900	168	20-320	185	71-300	171	42-300	210	124-260	162	81-275
1990	386	140-540	266	40-460	178	110-350	306	210-380	260	190-330	274	90-370

[a] All heights 999 centimeters or greater were recorded as 999 centimeters.

Acer macrophyllum was dominant at the start of the decade only on plots allotted to spot-clear and no site preparation treatments but was found the next year on a sprayed plot. Bigleaf maple increased in frequency and cover by the end of the decade in every treatment where it was present (table 41). The gain was almost exclusively in unburned areas; bigleaf rnaple was not present in burn areas initially, and only a single plant became dominant there over the 10-year span. Bigleaf maple was dominant on about four times as many transects at the end of the decade as at the beginning and responded best when not cut back.

This species averaged tallest, 821 centimeters in 1990, in the glyphosate-treated areas where it first appeared in 1981 as a single stem 13 centimeters tall. It averaged about 635 centimeters tall in the spot-clear and no-site-preparation treatments. As did vine maple, some bigleaf maple stems exceeded 1000 centimeters in height initially but lost height or faded away during the decade.

Adiantum pedatum was found in a dominant position on a single transect in the no-site-preparation treatment initially, was dominant there on two transects in 1981 and then on one again in 1982, 1983, and 1987. Height of maidenhair fern was 41, 27 and 67, 42, 55, and 70 centimeters in 1980, 1981, 1982, 1983, and 1987, respectively. This species thrives in moist shade and is not likely to be gone from the stand—just no longer tall enough to be a dominant.

Table 41—Frequency, cover, and height of *Acer macrophyllum* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
						Percent						
1980	1.9	1.3	0.8	0.4								
1980a	1.9	1.3										
1981	2.7	1.9	.8	.5	0.2	+[a]						
1982	2.9	2.3	.6	.4	.4	+						
1983	2.9	2.3	1.3	.8	.6	0.1						
1985	4.0	3.0	1.3	1.1	1.3	.3						
1987	4.6	3.2	2.1	1.6	1.5	.8						
1990	6.9	4.9	1.9	1.7	1.5	1.3					0.2	0.1
						Height (centimeters)						
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980	467	20-999[b]	135	32-260								
1980a	467	20-999										
1981	530	93-999	163	33-300	13	13						
1982	574	125-999	375	150-500	143	143						
1983	450	105-800	266	200-400	70	8-185						
1985	443	36-750	423	170-720	254	52-430						
1987	583	100-999	443	170-920	510	127-800						
1990	632	200-850	641	300-750	821	700-900					700	700

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.
[b] All heights 999 centimeters or greater were recorded as 999 centimeters.

Alnus rubra was present in low frequency and percentage of cover in all but the burn treatment at the start of the study (table 42). Dominance of red alder first decreased in every treatment, then slowly recovered, including establishment in the burn treatment. Red alder expanded rapidly from 1985 onward to constitute 14 to 31 percent of the dominant cover in individual treatments (fig. 25). Frequency and cover were about 17 and 14 percent, respectively, for the spot-cleared and unprepared areas; twice as much, 34 and 29 percent, for burned areas; and intermediate on those sprayed with glyphosate.

Stems exceeding 1000 centimeters in height were present for most of the decade on unprepared sites; elsewhere, red alder was represented initially by stems 11 to 400 centimeters in height. At the end of the decade, red alder in different treatments averaged 617 to 673 centimeters in height, and the tallest individuals were over 800 centimeters.

Red alder was not a prominent part of the total cover in the first 5 years; but in the following 5 years, it developed rapidly to become second to Douglas-fir in all treatments except for spot-cleared and unprepared areas. Obviously, disturbance favored establishment of red alder, which in some areas is likely to become the main cover.

Table 42—Frequency, cover, and height of *Alnus rubra* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980	2.3	1.5	1.3	0.3[a]	1.3	0.5			0.6	0.1	1.0	0.2
1980a	2.3	1.5	.2	+	1.3	.5					.4	.1
1981	1.9	1.0	.6	.1	1.0	.3					.2	+
1982	2.9	2.0	.2	.1	.2	.1			.4	+	.6	.1
1983	3.3	2.4	.6	+	.6	+	0.6	0.1	2.7	.8	1.5	.3
1985	6.7	3.9	4.2	1.5	3.5	.8	7.7	3.1	12.3	7.3	7.7	3.0
1987	10.6	7.1	10.0	6.2	12.7	6.2	19.4	9.0	24.0	15.2	19.6	10.4
1990	17.3	14.4	16.3	13.9	21.3	17.0	32.9	26.0	39.4	31.4	30.8	28.4
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980	596	19-999[b]	97	42-165	171	11-400			46	18-95	43	17-65
1980a	596	19-999	34	34	171	11-400					47	31-62
1981	519	20-999	82	34-135	98	51-200					120	120
1982	645	100-999	173	173	240	240			81	49-113	89	15-130
1983	556	72-999	160	59-230	37	17-48	131	110-160	153	53-240	122	56-200
1985	437	165-900	272	56-540	154	32-340	239	40-500	348	82-600	188	30-400
1987	547	50-999	413	80-840	339	86-550	338	50-650	390	80-820	355	30-830
1990	633	120-850	617	220-850	629	200-850	660	240-880	663	210-900	673	440-840

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.
[b] All heights 999 centimeters or greater were recorded as 999 centimeters.

Figure 25—Red alder expanded rapidly from 1985 on to constitute 14 to 31 percent of the dominant cover in individual treatments by 1990.

Anaphalis margaritacea was not dominant (and probably not even present) in any treatment area in 1980 and 1981. Pearly-everlasting was found dominant in all treatments in 1982 but only on a single transect in unprepared areas (table 43). In 1983, it was dominant in token amounts but only on unburned areas. In 1985 and 1987, it was again dominant in all treatments and averaged more than 1 percent of the total cover. By 1990, pearly-everlasting was dominant only on a single transect in each of three treatments. Clearly, this species invades site-prepared areas better than unprepared areas and can vary from zero or sparse to abundant in successive seasons.

Plants of pearly-everlasting found in 1982 were relatively short, averaging from 22 to 51 centimeters except in spot-cleared areas where the average was 86 centimeters. In 1985 and 1987, average height in unprepared sites was 73 and 83 centimeters, respectively, in site-prepared areas, 80 to 98 centimeters. Maximum heights in 1985 and 1987 varied widely, from 115 to 255 centimeters.

Table 43—Frequency, cover, and height of *Anaphalis margaritacea* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1982	0.2	+[a]	4.2	0.3	2.1	0.1	7.5	0.5	8.1	0.5	8.1	0.7
1983	.2	+	1.3	.2	.2	+						
1985	2.5	0.3	6.7	1.2	19.2	3.0	24.8	4.3	29.2	5.6	29.6	5.0
1987	1.5	.3	5.6	.8	8.5	1.4	20.2	3.5	18.3	3.8	20.0	3.1
1990			.2	+					.2	+	.2	+
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1982	22	22	86	46-141	36	14-65	40	10-82	51	10-97	51	8-109
1983			77	40-125								
1985	73	20-135	90	45-183	84	12-162	86	6-255	85	16-160	81	28-135
1987	83	17-115	86	25-185	86	36-175	80	30-190	92	35-183	98	35-175
1990			62	62					134	134	105	105

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Athyrium filix-femina first appeared as an incidental dominant in 1982 on one transect each in spot-cleared and broadcast-burned areas (table 44). From about 1985 to 1987, lady-fern was an incidental dominant in most site-preparation treatments, but such dominance occurrences were nearly over by 1990. Its occurrence and cover do not indicate that it was affected much by site preparation. Most incidental appearances of lady-fern among dominants were relatively late—in the last half of the decade.

Table 44—Frequency, cover, and height of *Athyrium filix-femina* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1982			0.2	+[a]			0.2	+				
1983			.2	+								
1985	0.2	0.1	.4	0.1	0.2	+			0.6	0.1	0.2	+
1987	1.0	.1	.4	+	.2	+			.6	.1	.2	+
1990	.2	.1	.2	+								
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1982			12	12			100	100				
1983			70	70								
1985	80	80	93	30-155	85	85			60	25-95	100	100
1987	106	75-130	40	40	42	42			123	72-174	175	175
1990	160	160	80	80								

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Average height of lady-fern ranged in different situations from 12 to 175 centimeters. The average and maximum heights are simply indicative; their basis is too sparse for any definitive information by treatment or year.

***Berberis* spp.** appeared as an incidental dominant on a spray plot in 1982 and later also in plots subjected to spot-clearing or burning (table 45). Although not uncommon, dominance of Oregongrape is limited and patchy in the Coast Ranges, and because it is relatively short (14 to 35 cm), it usually does not retain dominant status for very long.

Blechnum spicant first appeared in 1982 as an incidental dominant in the slash-and-burn treatment and by 1985 in most other treatments (table 46). By 1987, deer-fern had lost most of its minor status as a dominant but probably still remained present in a limited number of locations. Its height ranged from 13 to 123 centimeters.

***Carex* spp.** were among the incidental dominants from 1982 to 1985; sedges were found more in burned than in unburned areas:

Site preparation	Year	Frequency	Cover	Average height	Range
		--- *Percent* ---		--- *Centimeters* ---	
None	1983	0.4	+	120	87-152
Burn	1982	.6	0.4	172	157-195
Slash and burn	1985	1.0	.4	100	53-130
Spray and burn	1983	.4	.2	74	48-100

They were relatively tall, ranging in height from 48 to 195 centimeters.

Table 45—Frequency, cover, and height of *Berberis* spp. by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1981					0.2	+[a]						
1982			0.2	+	.2	+						
1983			.2	+	.2	+						
1985					.4	+			0.4	+		
1987					.2	+			.4	0.1		
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1981					24	24						
1982			22	22	14	14						
1983					25	25						
1985					30	25-35			29	28-30		
1987									29	26-32		

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Table 46—Frequency, cover, and height of *Blechnum spicant* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1982									0.4	+[a]		
1983	0.4	+							.4	0.1		
1985	.2	+	0.6	0.1	0.6	0.1	0.2	+	.8	+		
1987			.2	+	.2	+						
1990			.4	.1								
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1982									76	67-84		
1983	43	43							67	60-74		
1985	52	52	50	13-123	30	30			94	94		
1987			67	67	86	86						
1990			31	22-40								

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

***Cirsium* spp.** invaded plots of most site-preparation treatments in 1981, became common dominants in 1982 and 1983 in all treatments, and declined slowly thereafter (table 47). Thistle dominance in peak years was lowest in spot-cleared areas, next lowest on unprepared sites, and most abundant in the other four treatments. Their average and maximum heights differed by treatment and year without any really discernable pattern, ranging from 11 to 138 and from 12 to 263 centimeters, respectively.

Table 47—Frequency, cover, and height of *Cirsium* spp. by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980a			0.2	+[a]								
1981	2.5	0.3	.8	0.1			4.0	0.6	3.8	0.7	1.3	0.3
1982	4.2	.8	.6	+	7.5	0.8	7.1	.6	5.4	.5	8.3	.9
1983	4.2	.6	1.0	.1	4.6	.4	11.5	1.3	10.2	1.8	8.3	1.2
1985	1.9	.2	.4	+	1.0	.1	.2	+	.6	.1	1.5	.1
1987	.8	.1	.2	+	.8	.2	.2	+	1.0	.2	.2	+
1990	.2	.1										
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980a			12	12								
1981	106	34-235	89	64-111			98	23-160	97	32-182	94	18-164
1982	96	59-135	146	146	76	6-134	31	5-95	50	12-96	48	4-107
1983	95	52-160	56	50-62	45	3-98	69	14-120	100	22-263	84	30-170
1985	71	25-93			91	41-127	50	50	58	35-90	83	11-176
1987	85	60-120	130	130	109	100-122			138	84-222	11	11
1990	130	130										

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Corylus cornuta* var. *californica was dominant on a single transect in a burn plot at the start of the study and slowly gained through 1987 to be represented in low numbers in every treatment (table 48). Frequency and cover of California hazel was highest in the spray and no-preparation areas and lowest in two of the three burn treatments. By 1990, it had lost any dominant position in all burn treatments and was a declining portion of the dominant cover in the other three treatments.

Height development of California hazel was much less in burned areas than in unburned areas. The most likely reason for the difference is more browsing on new plants. By 1990, average heights of 360 to 528 centimeters had been attained, and a maximum height of 750 centimeters was found. This species still has substantially more height potential as a subdominant among the dominant conifers.

Table 48—Frequency, cover, and height of *Corylus cornuta* var. *californica* by site preparation and year

Year	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980							0.2	0.1				
1980a												
1981	0.2	0.2			0.4	+[a]	.2	+				
1982	.4	.2			1.0	0.3	.4	.1				
1983	.4	.3	0.2	+	1.3	.4	.2	+				
1985	1.0	.9	.4	0.1	1.3	.4	.6	.1			.2	.1
1987	1.3	1.2	.6	.2	1.3	.4	.2	+	0.2	+	.2	.1
1990	.8	.7	.6	.1	.4	.3						
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980							42	42				
1980a												
1981	500	500			46	38-54	57	57				
1982	347	43-650			104	60-173	45	40-49				
1983	285	70-500	105	105	105	42-175	36	36				
1985	372	320-460	248	155-340	161	100-263	61	30-120			240	240
1987	518	320-700	232	180-265	220	110-350	48	48	100	100	260	260
1990	528	400-750	363	250-440	360	350-370						

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Dicentra formosa was a widespread but not abundant component of the residual vegetation in every treatment (table 49). Spot-clearing increased the frequency and cover of bleedingheart as a dominant for a short time whereas burning first reduced its dominance, followed by increases in 1981 and 1982. Bleedingheart was less affected by spraying than by burning and did not retain dominance in unprepared areas beyond the initial year. As a relatively short plant, it retained dominant positions longest in site-prepared areas; but even here, it most often was overtopped by 1983. This species thrives in sun-dappled understory locations but is shaded out under the youthful closed canopies of conifers and alders.

Average heights for bleedingheart ranged from 12 to 32 centimeters with those for burned areas tending to be shorter than those for spot-cleared or sprayed areas. Maximum heights were under 40 centimeters with three exceptions—52, 66, and 132 centimeters. A maximum height of 132 centimeters is still plausible, but it is so much greater than others as to raise concern about an observational or recording error.

Digitalis purpurea was not present in 1980, became scatteringly evident in 1981, and became a colorful and prominent dominant in all treatments for most of the decade (table 50). Foxglove was dominant on 10 percent or more of the transects one or more times in every treatment, and its 1985 frequency and cover were notably higher in the spray treatment than anywhere else (43.1 and 7.8 vs. 11.9 and 1.3 percent). It averaged more than 1 percent of the total dominant cover in 1983, 1985, and 1987. Many stems were required for these narrow, largely single-stalked plants to aggregate that much cover (fig. 26).

Table 49—Frequency, cover, and height of *Dicentra formosa* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980	0.6	0.1	3.8	0.3	3.5	0.5	1.0	0.1	5.2	0.4	3.1	0.2
1980a	.6	.1	10.2	.9	3.5	.5	.2	+[a]	.2	+		
1981			1.7	.1	2.5	.2	.8	+	1.5	.1	.4	+
1982			1.0	+	5.0	.4	3.5	.2	2.1	.2	3.1	.2
1983			1.0	.1					.2	+		
1985												
1987			.2	+								
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980	16	12-24	21	10-36	23	8-66	19	10-30	16	6-35	16	7-39
1980a	16	12-24	17	6-38	23	8-66			16	16		
1981			30	22-38	20	10-33	15	7-24	12	7-19	16	15-17
1982			16	14-18	22	5-52	17	11-24	32	8-132	15	6-26
1983			28	25-31					16	16		
1985												
1987			20	20								

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Table 50—Frequency, cover, and height of *Digitalis purpurea* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980a			1.3	0.1								
1981	0.8	0.1	1.5	.2			0.2	+[a]	0.4	+	1.5	0.2
1982	6.0	.5	9.8	1.5	3.1	0.3	3.5	0.5	3.8	0.4	10.8	1.3
1983	13.1	2.3	21.3	4.5	14.0	1.5	8.3	1.1	10.4	1.4	8.5	.9
1985	9.6	1.1	11.9	1.1	43.1	7.8	11.0	1.0	11.7	1.3	11.9	1.0
1987	5.8	.5	10.4	1.3	26.3	3.9	9.4	.8	11.7	1.2	9.8	.8
1990	1.3	.2	3.3	.9	2.7	.7	2.1	.6	.8	.2	.6	.1
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980a			23	9-29								
1981	62	29-105	37	9-110			26	26	25	25	44	11-120
1982	83	8-205	55	12-206	82	13-240	121	12-211	120	25-173	121	10-210
1983	106	10-250	104	6-280	59	7-230	112	7-230	96	9-250	91	5-200
1985	95	10-225	101	7-200	100	9-210	76	8-205	69	10-190	70	10-180
1987	99	8-220	72	10-220	122	7-250	83	8-202	106	16-250	86	12-221
1990	46	14-110	100	20-280	135	20-220	67	12-180	211	168-234	130	40-220

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Figure 26—Though sparse initially, foxglove became a colorful and prominent dominant in all treatments for most of the decade.

The range of sizes represented by the average heights provide abundant evidence that dominant foxgloves were a heavy mixture of immature and mature plants. The averages, from 23 to 211 centimeters, describe general height levels attained by this species in early to late summer when reexaminations were made in different years. The taller maximum heights observed, from about 180 to 280 centimeters, probably represent better the mature heights attained by this species.

Echinocystis lobata, a climbing vine not present before, was a surprise among the dominants in 1982 (table 51). Wild cucumber was found as an incidental dominant in all but the spray-and-burn areas, being most abundant in areas treated with glyphosate. The leaves of this species provide an innate height of about 10 to 20 centimeters; dominance attained as well as its average and maximum heights (up to 240 cm) represent the position and heights this species gained growing over slash or logs and up stems of other species.

***Epilobium* spp.** were not dominant in 1980, flourished in all treatments in 1981 and 1982 to average more than 1 percent of the total cover, and then occurred in minor numbers through 1987 (table 52). Frequency of fireweeds in 1981 and 1982 averaged more than twice as high in burned areas as in those unburned (29.3 and 34.0 vs. 8.8 and 15.3 percent), and cover differences were greater (8.2 and 11.0 vs. 1.4 and 3.2 percent). Occurrence after 1982 was more common in the burned or sprayed areas than in the spot-cleared or no-preparation areas.

Average heights for fireweed species also represent a mixture of immature and mature plants. Common average heights of fireweed ranged from about 80 to 136 centimeters, common maximums from near 120 to 220 centimeters.

Table 51—Frequency, cover, and height of *Echinocystis lobata* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1982	0.8	0.2	0.2	+[a]	2.1	0.5	0.6	+	1.0	0.4		
1983	1.5	.2	.2	0.1	1.9	.7	.6	0.1	1.3	.4		
1985					.4	.1	.2	.1				
1987	.4	.1	.2	.2	2.1	.8	.6	.2	.2	+		
1990							.4	.2	.2	.1		
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1982	55	23-88	131	131	42	22-64	85	65-105	39	22-65		
1983	85	46-180	90	90	53	25-104	78	62-93	69	42-140		
1985					98	51-145	130	130				
1987	80	80	240	240	135	40-240	120	50-180	120	120		
1990							171	122-220	160	160		

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Table 52—Frequency, cover, and height of *Epilobium* spp. by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980a			4.2	0.6								
1981	9.4	1.5	13.8	2.3	3.3	0.3	25.2	5.1	29.2	10.0	33.5	9.5
1982	7.5	1.0	17.1	3.5	21.5	5.0	34.4	10.6	32.9	11.1	34.8	11.5
1983	.2	+[a]			.2	+	1.7	.1	.6	+	.6	+
1985			.4	+	1.7	.2	2.5	.2	3.8	.3	1.5	.1
1987	.4	.1			.2	+	.2	+	.4	+	.6	+
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980a			83	11-175								
1981	118	19-217	84	10-175	52	15-133	97	9-191	95	15-180	78	12-160
1982	135	36-181	136	42-244	104	8-156	106	6-210	112	20-228	116	24-223
1983					36	36	47	22-92	81	64-98	73	26-120
1985					71	40-105	83	35-120	73	35-130	98	40-150
1987	85	60-110							105	105	53	45-60

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

***Equisetum* spp.** were found as incidental dominants in 1982, 1985, and 1987. Horsetail frequencies were somewhat more numerous in unburned areas than in burned areas:

Site preparation	Year	Frequency	Cover	Average height	Range
		--- *Percent* ---		--- *Centimeters* ---	
None	1985	0.8	0.1	61	40-80
	1987	1.5	.3	67	32-110
Spot-clear	1987	.2	.1	168	168
Slash and burn	1987	.6	.1	132	95-164
Spray and burn	1982	.4	.2	59	59
	1987	.6	.5	156	133-184

Some plants were very tall—up to 184 centimeters. Appearance of horsetails among dominant plants was largely a 1987 event; on coastal sites, they are relatively common as subdominants.

Erechtites arguta first appeared in 1981 as scattered dominants in all treatments (table 53). Burnweed frequency was substantially greater in 1982 and 1983, particularly in burned or sprayed areas. The species averaged more than 1-percent cover in 1982. Dominance of burnweed was infrequent in 1985 and was not found thereafter.

Average height of burnweed in different years and treatments ranged from 18 to 93 centimeters. The averages reflect a mixture of heights from immature and mature plants. Maximum heights of larger plants ranged from about 90 to 181 centimeters.

Table 53—Frequency, cover, and height of *Erechtites arguta* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1981	1.5	0.1	0.2	+[a]	2.3	0.2	0.4	+	0.6	+	0.8	+
1982	4.8	.4	2.9	0.4	19.4	2.9	19.8	1.3	12.5	1.0	5.6	0.3
1983	3.5	.5	1.7	.2	17.3	2.4	6.9	.6	8.8	.8	3.3	.3
1985					2.1	.3	1.0	.1			.6	+
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1981	28	17-45			40	23-78	18	16-19	65	15-114	37	33-41
1982	35	7-71	93	16-181	65	9-159	36	6-165	35	9-104	43	9-100
1983	54	35-70	47	30-80	46	13-114	30	8-75	46	13-89	49	15-95
1985					90	55-112	91	76-100			23	23

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Gaultheria shallon was continuously present in all treatments throughout the decade (table 54). Minor reductions in salal frequency and cover from 1980 to 1982 without any site preparation indicate this species went through a minor postlogging stabilization period. Burning substantially reduced the frequency and cover of salal, but recovery reached preburn levels by 1985. Spot-clearing reduced its cover for less than one season; in fact, cutting of competing species may have even increased its frequency as a dominant. Effects of spray on competing species may be reflected by the rapid increase in frequency and cover of salal after application of glyphosate. Only in the spray treatment did the frequency of salal double and its cover reach nearly four times the original level. By 1990, dominance of salal was decreasing in all treatments.

This species comprised more than 1 percent of the cover at all examinations except the one immediately after site preparation. Because the second examination was made after site preparation but before a new growing season started, the burned or cut stubs of salal were actually there ready to bounce back by midseason. Salal development was low following spot-clearing and greatest after spraying, where a release effect may have aided this species.

Table 54—Frequency, cover, and height of *Gaultheria shallon* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980	9.4	2.0	4.2	0.6	12.9	1.8	9.2	2.1	8.8	1.6	11.0	3.2
1980a	9.4	2.0	5.2	.4	12.9	1.8	4.8	.9	1.7	.2	.8	.1
1981	7.5	1.8	4.4	.6	19.0	3.9	3.8	.8	1.7	.2	1.7	.2
1982	6.7	1.9	6.0	.7	21.0	4.7	7.1	1.2	4.4	.5	7.9	.7
1983	8.8	3.2	7.7	1.6	22.5	5.4	7.3	1.1	5.2	.7	8.5	1.5
1985	9.4	2.7	6.3	1.2	25.2	7.1	10.8	2.3	9.0	1.7	11.7	3.2
1987	9.0	3.1	7.3	2.0	20.6	5.0	10.2	2.6	6.5	1.5	11.9	3.1
1990	6.5	2.1	2.9	1.0	4.4	1.9	4.0	1.8	1.0	.4	5.6	2.6
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980	48	11-173	33	12-67	31	7-135	32	10-129	29	8-111	54	10-255
1980a	48	11-173	17	7-41	31	7-135	31	13-69	38	23-53	28	16-51
1981	45	12-152	16	7-30	27	6-177	26	7-59	48	10-205	14	10-18
1982	52	15-106	25	9-65	29	5-76	30	11-70	27	8-50	23	10-36
1983	65	10-137	47	12-140	39	10-131	36	7-115	24	7-41	31	10-50
1985	82	30-150	61	29-110	43	7-100	48	11-108	46	20-146	47	14-123
1987	100	40-300	98	45-175	58	10-175	68	20-140	58	24-140	64	9-140
1990	135	50-210	132	53-200	109	25-240	82	22-135	114	60-165	105	25-176

Before site preparation, average height of salal ranged from 29 to 54 centimeters among treatments, with the averages for the spray-and-burn and no-preparation treatment notably higher than the others. The average for the no-preparation treatment dropped slightly and then climbed gradually to 135 centimeters by 1990. There was a somewhat greater drop in average height in all site-preparation treatments and then a generally similar steady gain in height. Average height in the spot-clear treatment eventually was close to the average for no site preparation. The 1990 averages for the other four treatments were less by at least 20 centimeters. Maximum heights in 1990 ranged from 135 to 240 centimeters.

***Gramineae* spp.** were present before site preparation in frequencies of 5 percent or less and cover under 0.7 percent except in plots allotted to the spray-and-burn treatment where amounts were more than twice as high (table 55). Cover of grasses was temporarily reduced by broadcast burning but not by any of the other site treatments. Increases were rapid in most instances, reaching highest frequencies by 1982 and highest percentage of cover by 1983. At peak times, frequency and cover of grasses averaged almost twice as high for burned areas and sprayed areas as for spot-cleared and unprepared areas (frequency 49.2, cover 11.6 vs. 25.2 and 6.1). Their dominance declined gradually in all treatments from 1983 on, but grasses still averaged more than 1-percent cover in 1990.

Table 55—Frequency, cover, and height of *Gramineae* spp. by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980	4.0	0.5	3.1	0.5	5.2	0.6	2.1	0.5	5.0	0.7	11.0	3.1
1980a	4.0	.5	13.3	1.8	5.2	.6	.2	+[a]	2.1	.3	5.2	1.9
1981	13.1	2.7	22.1	3.8	13.1	1.7	11.0	1.4	16.9	3.1	28.1	8.2
1982	25.2	5.8	30.2	5.7	47.9	10.9	45.4	8.2	49.6	10.6	55.2	12.2
1983	23.5	8.0	21.9	4.7	46.5	13.0	44.0	11.1	48.8	11.8	55.8	15.1
1985	23.1	6.8	16.9	3.9	47.9	11.8	35.8	8.1	29.2	5.7	35.8	8.0
1987	19.0	5.0	15.8	3.1	27.9	6.3	23.1	4.7	20.0	4.1	26.3	4.7
1990	4.2	1.1	6.3	1.7	5.8	2.0	5.6	2.0	1.9	.5	1.7	.7
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980	22	7-42	34	5-90	28	12-56	26	7-63	34	8-84	32	9-63
1980a	22	7-42	19	6-50	28	12-56			23	9-43	28	10-58
1981	39	8-130	43	8-140	29	5-88	48	9-125	55	6-140	60	4-142
1982	58	16-187	58	8-205	68	8-164	61	7-148	60	13-165	62	9-160
1983	69	4-162	70	20-140	67	10-137	73	12-165	75	10-174	80	9-164
1985	72	12-152	51	5-140	74	5-170	56	10-123	65	15-120	68	5-190
1987	72	14-180	44	10-122	65	14-176	58	6-160	71	12-173	71	16-150
1990	28	10-60	33	10-130	39	12-120	36	10-170	15	8-32	52	20-100

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Average height of grasses peaked in 1983 in the burn and spot-clear treatments, in 1985 in the other two treatments, and ranged from 70 to 80 centimeters, two to three times as tall as averages at the initial examination. By 1990, average heights were down substantially, even lower than initially in some instances. Maximum heights were impressive, exceeding 180 centimeters.

Holodiscus discolor was hardly represented among dominant species at the start of the study, and the few increases did not boost it from this category (table 56). Oceanspray eventually appeared in 1985 and 1987 as an incidental dominant in all treatments but spot-clear but by 1990 retained dominance on just one transect. Heights attained toward the end of the decade ranged from 72 to 280 centimeters.

Table 56—Frequency, cover, and height of *Holodiscus discolor* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980	0.2	+[a]							0.2	+		
1980a	.2	+										
1981												
1982									.2	+		
1983									.2	+		
1985	.2	+			0.2	+	0.2	+	.2	0.1	0.4	0.1
1987	.2	0.1			.2	+	.6	+	.2	+	.4	+
1990									.2	+		
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980	49	49							263	263		
1980a	49	49										
1981												
1982									149	149		
1983									147	147		
1985	120	120			78	78	40	40	150	150	45	40-50
1987	180	180			90	90	120	72-176	210	210	105	80-130
1990									280	280		

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

***Juncus* spp.** were found dominant on a few transects in burned and unburned areas in 1982, 1983, and 1985 (table 57). Given the infrequent occurrence of rushes and the nature of their growth form, the amount of cover they provided was substantial. Their average heights ranged from 61 to 86 centimeters, and maximum heights over 100 centimeters were found.

***Lotus* spp.** appeared on most disturbed sites in 1982, were not dominant anywhere in 1983, were present in all treatments in 1985, and decreased to incidental dominants by 1990 (table 58). Deervetches were dominant in 1985 on about one-fifth of the transects in burned areas, only one-third as many in sprayed areas, and were no more than incidental occurrences in spot-cleared and unprepared areas. Cover in 1985 reached 3.0 percent in slash-and-burn areas and averaged more than 1 percent for all treatments.

Table 57—Frequency, cover, and height of *Juncus* spp. by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1982	0.8	0.1	1.3	0.4					1.9	0.7		
1983	1.3	.4	1.5	.6					5.0	1.4		
1985			1.3	.5					2.7	1.2	0.6	0.1
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1982	71	69-72	70	44-85					61	21-81		
1983	86	70-100	85	59-143					67	35-107		
1985			68	50-86					70	40-100	79	70-86

Table 58—Frequency, cover, and height of *Lotus* spp. by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1982					1.7	0.1	12.7	1.4	13.5	1.2	5.6	0.4
1983												
1985	0.4	+[a]	1.3	0.1	6.5	.6	21.0	2.8	19.8	3.0	23.3	2.7
1987			.6	.1	5.0	.3	5.8	.4	6.5	.4	9.2	.7
1990			.2	+			.6	+				
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1982					16	7-25	23	7-57	16	7-39	19	10-43
1983												
1985	48	36-60	41	25-52	44	13-120	50	11-105	54	3-165	48	13-97
1987			90	90	48	7-130	35	6-85	47	14-110	50	10-100
1990			52	52			56	56				

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Average heights ranged from 16 to 23 centimeters in 1982 and from 35 to 54 centimeters in later years. Maximum heights ranged from 25 to 57 centimeters in 1982 and from 52 to 165 centimeters in 1985 to 1990.

***Lupinus* spp.** were found as incidental dominants, primarily in burned or sprayed areas, from 1981 to 1987, except for 1983 (table 59). Lupines generally were short; average and maximum heights were variable—all less than 100 centimeters.

Lysichitum americanum was an incidental dominant in burn and slash-and-burn areas at the start of the study. Skunk cabbage endured through broadcast burning and was found among dominant vegetation until 1985:

Site preparation	Year	Frequency	Cover	Average height	Range
		--- Percent ---		*--- Centimeters ---*	
Spot-clear	1981	0.2	0.1	20	20
Burn	1980	.2	+	37	37
Slash and burn	1980	1.0	.2	31	16-52
	1980a	.2	+	58	58
	1981	1.3	.2	26	6-71
	1982	.2	.1		
	1983	.4	+	220	220
	1985	.2	+	125	125
Spray and burn	1985	.2	+	240	240

The plants found in 1980-81 were short, generally less than 60 centimeters; but later the dominant individuals were 125 to 240 centimeters tall.

Menziesia ferruginea was an infrequent dominant among residual vegetation in all treatments (table 60). Dominance of false azalea increased slightly over the years in unburned areas, but burning eliminated it as a dominant for the decade. Spraying and spot-clearing reduced its dominance for a time, but eventually it increased to about the original frequency or slightly greater. False azalea did not demonstrate as much recuperative ability as did several associated shrubs.

Average heights of false azalea increased on unprepared sites from 18 centimeters in 1980 to 295 centimeters in 1990. Initially, heights of false azalea were substantially greater in other treatments, but by 1990, they did not exceed heights on unprepared sites.

***Montia* spp.**, distinctive succulent herbs, developed rapidly on cleared areas and were present as 5 percent or more of the total cover in all treatments at the start of the study (table 61). Burning temporarily eliminated most candy flower, but by mid-1981, this species occurred as frequently and with similar amounts of cover on burned areas as before burning. Aerial spraying of glyphosate was followed in the next season, 1981, by the highest frequency and cover of candy flower, 62.5 and 15.3 percent, respectively. The dominance of candy flower was very fleeting, however. By 1981, slight decline was evident in unprepared and spot-cleared areas. By midseason 1982, the frequency and cover of candy flower had decreased markedly in all treatments but still averaged 1-percent cover. It was no longer found as a dominant on burned areas in 1983 and only as an incidental dominant on unburned areas until 1985.

Table 59—Frequency, cover, and height of *Lupinus* spp. by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1981					0.2	+					2.3	0.3
1982			0.2	+[a]	.4	+	1.5	0.1				
1985			.2	0.1	.2	+	.4	.1	0.2	+	.8	+
1987					.4	+	.4	+			.4	+
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1981					26	26						
1982					27	27	13	9-16			19	13-33
1985			95	95	60	60	50	48-51	9	9	29	13-52
1987					43	20-65	80	80			28	28

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Table 60—Frequency, cover, and height of *Menziesia ferruginea* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980	0.2	+[a]	1.0	0.1	0.6	0.2	0.2	0.1	0.2	+	0.2	+
1980a	.2	+	.4	+	.6	.2						
1981	.4	+	.4	+								
1982	.4	+	.4	+								
1983	.2	+	.2	+								
1985	.8	.1	.8	.1	1.5	.2						
1987	1.3	.2	.6	.2	1.7	.2						
1990	.4	.1	.6	.2	.6	.2						
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980	18	18	72	31-95	131	51-250	130	130	91	91	48	48
1980a	18	18	42	32-52	131	51-250						
1981	59	26-91	42	32-52								
1982	20	20	114	114								
1983	110	110	51	51								
1985	160	25-215	163	142-180	58	17-130						
1987	200	85-300	228	210-240	118	12-210						
1990	295	260-330	300	300	160	130-220						

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Table 61—Frequency, cover, and height of *Montia* spp. by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980	36.0	6.5	29.4	5.9	33.8	5.6	22.5	4.8	24.4	5.1	29.4	8.4
1980a	36.0	6.5	34.8	4.7	33.8	5.6			.2	+[a]		
1981	26.0	4.5	28.8	4.4	62.5	15.3	32.9	4.1	23.8	3.0	44.0	10.0
1982	4.8	.3	4.6	.3	32.9	3.5	13.5	.9	6.0	.5	7.5	.4
1983	.6	.1	.2	+	5.6	.6						
1985					.2	+						
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980	14	5-33	14	4-32	16	6-47	15	5-52	16	6-30	15	4-34
1980a	14	5-33	15	5-36	16	6-47			20	20		
1981	17	6-31	15	4-40	17	5-45	16	3-36	12	5-30	14	5-28
1982	15	7-29	12	7-23	18	6-38	16	9-38	19	10-36	12	5-23
1983	20	20			22	5-92						
1985					32	32						

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Candy flower is generally a short, fleshy-stemmed plant, usually less than 30 centimeters tall. Initial and posttreatment heights did not differ much among treatments nor during the few years it was dominant. Maximum heights ranged from 23 to 92 centimeters.

Osmaronia cerasiformis was not a dominant among the residual vegetation in any treatment area; it appeared as an incidental dominant (frequency 0.6 to 1.7) in all burn treatments only in 1982, comprising 0.1 percent of the cover in each treatment. Indian plum was dominant on a single transect in the sprayed area in 1983. Heights averaged from 23 to 94 centimeters, with a maximum of 151 centimeters. Typically, Indian plum is found as an understory or border shrub rather than as an aggressive dominant.

Oxalis oregana is a common understory plant not generally found in a dominant position. Wood-sorrel dominance increased slightly from 1980 to 1982 in three of the four treatments where it was found; it increased after spot-clearing or broadcast burning but decreased after spraying (table 62). After 1982, wood-sorrel quickly lost dominance as taller vegetation increased and overtopped it. Its heights ranged from 5 to 26 centimeters.

Picea sitchensis was dominant on a single spray transect in 1980 and gradually increased to be present in all but one treatment by 1990 (table 63). Sitka spruce was more often dominant in unburned than in burned areas. Initially represented by a 44-centimeter seedling, the tallest Sitka spruce was 540 centimeters in height by 1990.

Table 62—Frequency, cover, and height of *Oxalis oregana* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980	0.4	+[a]	0.2	+	0.6	0.1			0.2	+		
1980a	.4	+	.2	+	.6	.1						
1981	1.3	0.1	.2	+					.4	+		
1982	1.7	.2	.4	+	.2	+			1.0	0.1	0.2	+
1983												
1985												
1987	.2	+							.2	+		
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980	10	8-11	17	17	9	7-12			5	5		
1980a	10	8-11			9	7-12						
1981	12	10-13										
1982	25	25	8	8	11	11			17	17		
1983												
1985												
1987	8	8							26	26		

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Table 63—Frequency, cover, and height of *Picea sitchensis* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980					0.2	+[a]						
1980a					.2	+						
1981												
1982	0.2	0.2										
1983					.2	+						
1985	.4	+	0.6	0.2	1.3	0.2			0.2	+		
1987	.8	.1	.6	.3	1.0	.4	0.2	0.1	.2	+		
1990	1.0	.3	1.5	.8	1.9	.8	.2	.1	.4	0.1		
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980					44	44						
1980a					44	44						
1981												
1982	189	189										
1983												
1985	128	100-155	117	90-150	136	60-210						
1987	187	93-320	248	210-300	228	100-420	220	220	160	160		
1990	258	142-320	259	150-380	283	40-480	540	540	280	80-480		

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Polystichum munitum was a dominant species on one-fourth or more of the transects in all treatments at the beginning of the study (table 64). Dominance of sword-fern declined slightly each year on unprepared sites until 1985 and more rapidly thereafter. Though frequency dropped each year, cover of sword-fern increased slightly on unprepared sites in 1981 and remained as 6 to 7 percent of the total until 1985. Spot-clearing temporarily reduced frequency and cover of sword-fern, but they increased in 1981. Subsequent responses nearly paralleled the trend for no site preparation. Broadcast burning reduced the frequency and cover of sword-fern to low levels. Its frequency rebounded after burning to average about 60 to 75 percent as much as for no site preparation, but amount of cover remained less than half as much. Spraying with glyphosate reduced the frequency of sword-fern by half, and total cover was reduced by two-thirds. A declining trend occurred in all site-prepared areas similar to the trend in unprepared areas from about 1983 onward.

Site preparation adversely affected the average height of sword-fern throughout the decade (table 64). In 1980, sword-fern averaged around 60 centimeters in height in all treatments; in 1990, its total height averaged 121 centimeters in areas receiving no site preparation, 105 centimeters in spot-cleared areas, and 100 centimeters or less in all other treatments. The smallest increase in average height over the decade (7 cm) took place in the burn-only treatment.

Table 64—Frequency, cover, and height of *Polystichum munitum* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980	28.5	5.7	25.0	5.0	36.0	6.9	35.2	7.8	27.9	5.3	29.4	6.1
1980a	28.5	5.7	20.4	2.3	36.0	6.9	3.1	.5	4.2	.7	1.5	.2
1981	27.9	7.1	29.4	6.6	29.8	4.9	11.7	1.7	13.1	1.7	13.3	1.5
1982	25.8	6.5	23.8	5.8	18.3	2.3	16.5	2.5	15.2	2.1	13.5	1.8
1983	21.3	6.3	25.2	6.4	18.8	3.4	18.3	3.1	14.6	2.2	16.7	2.4
1985	20.0	6.4	20.0	5.7	20.8	3.1	16.5	2.3	11.3	1.5	13.5	1.9
1987	13.5	4.3	16.7	3.4	15.8	2.0	7.1	.8	6.9	.8	5.8	.8
1990	4.4	1.9	4.8	1.2	3.8	.9	2.7	.5	1.0	.1	1.5	.3
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980	59	12-116	62	10-117	61	6-125	66	11-119	59	12-113	58	11-220
1980a	59	12-116	39	7-93	61	6-125	64	26-95	63	20-96	57	14-72
1981	76	20-170	66	15-182	59	20-110	51	17-120	51	16-101	42	8-118
1982	78	13-141	80	15-126	59	17-118	58	16-125	64	21-178	52	10-96
1983	93	30-144	89	30-240	65	9-145	67	10-110	70	17-142	64	23-105
1985	93	9-140	93	25-160	63	19-142	66	15-168	67	10-148	68	26-130
1987	102	28-165	104	35-170	70	20-130	74	25-130	87	15-270	87	12-150
1990	121	34-170	105	35-180	82	22-166	73	32-165	100	76-112	98	78-130

Although burning or spraying physically reduced the frequency, cover, and height of sword-fern, its subsequent growth performance and dominance may also have been differentially influenced by browsing and the relative amount, vigor, and height of competitors that developed in the different site-preparation treatments. Sword-fern was a major component of the initial dominant vegetation, regained that role after all site preparations, and, though losing dominance in the latter part of the decade, is still present in the understory wherever there is sufficient light.

***Prunus* spp.** were present as scattered individuals in 1980, and their frequency increased a little during the decade (table 65). The increase occurred primarily in burned areas, but by 1990, cherry and plum species had lost the temporary dominant positions they held in these stands. Individuals present in 1980 ranged from 18 to 87 centimeters in height; those still dominant in 1990 ranged from 380 to 460 centimeters.

Table 65—Frequency, cover, and height of *Prunus* spp. by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980	0.2	+[a]			0.2	+	0.2	0.1				
1980a	.2	+			.2	+						
1981	.4	+	0.2	0.1			.2	+				
1982					.4	+	2.9	.1	1.3	0.1	0.4	+
1983							1.5	.1	.6	+	.2	+
1985	.6	.1	.2	+			1.7	.1	.2	+	.6	+
1987			.2	.1			.4	+	.8	.1	.2	+
1990	.2	.2	.2	.1								
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980	33	33			18	18	87	87				
1980a	33	33			18	18						
1981	81	23-138	240	240			43	43				
1982					34	25-43	19	5-42	26	10-41	18	15-20
1983							50	40-67	35	23-55	22	22
1985	203	70-300	23	23			36	23-50	42	42	30	30
1987			500	500			144	77-210	110	80-140	60	60
1990	460	460	380	380								

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Pseudotsuga menziesii was not represented in the residual stands; large stems had been harvested, and regeneration was not present. Thus, the response of Douglas-fir starts with the year it was planted, 1981. By the middle of the first season, Douglas-fir ranged in frequency from 15 to 28 percent, in cover from 0.9 to 1.9 percent (table 66). A decade later, frequencies ranged from 44 to 72 percent and cover from 34 to 62 percent. Areas not given site preparation had the lowest frequency and cover of Douglas-fir, and spot-cleared areas were next lowest. Sprayed areas averaged the highest frequency and cover. Douglas-fir gained dominance relatively rapidly in most treatments; by 1985 its cover comprised about 25 percent of the total on burned or sprayed areas (fig. 27), by 1990 from 56 to 62 percent.

Table 66—Frequency, cover, and height of *Pseudotsuga menziesii* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1981	14.6	0.9	22.7	1.6	28.3	1.8	23.8	1.3	28.3	1.9	24.2	1.6
1982	17.7	1.3	22.7	1.6	33.5	2.5	37.3	3.3	36.7	3.1	42.1	3.6
1983	20.0	2.7	27.9	3.9	43.5	6.6	48.8	7.7	46.9	7.5	56.3	8.5
1985	38.8	10.2	42.5	11.9	68.8	24.6	68.8	25.9	65.4	24.3	71.3	27.0
1987	44.0	20.5	50.8	24.0	71.0	44.3	71.9	47.7	68.1	45.0	74.8	46.2
1990	44.2	34.2	51.5	40.7	71.7	61.8	68.8	55.6	64.8	56.6	65.8	57.7
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1981	56	33-78	49	27-89	49	28-80	48	19-73	50	22-68	46	25-76
1982	72	29-170	73	17-138	63	7-115	69	20-155	65	11-187	69	30-144
1983	110	22-213	101	20-193	87	24-193	100	7-203	93	17-200	91	17-180
1985	157	60-290	173	52-340	132	60-280	159	43-300	161	20-320	157	65-405
1987	240	85-500	242	48-450	254	40-550	281	60-500	269	90-730	274	90-550
1990	453	27-700	464	100-700	469	60-800	521	140-750	546	150-800	517	102-820

Figure 27—Douglas-fir gained dominance relatively rapidly in most treatments. By the fifth season, its cover comprised about 25 percent of the total on burned or sprayed areas.

Average height of Douglas-fir increased about eightfold from 1981 to 1990 without site preparation, over ninefold after spot-clearing or aerial spraying, and about elevenfold after broadcast burning. These averages are not comparable to the height averages reported in the tree growth section. Rather, they represent the heights of plant parts that were dominant over the transect lines. Thus, these height values are on the same basis as that obtained for competing species.

Pteridium aquilinum was a common component of the dominant cover at the start of the study; but the frequency and cover of bracken-fern varied substantially among different treatments, being highest on unprepared areas and lowest on those to be spot-cleared (table 67). Cover of bracken-fern doubled by 1982 on unprepared areas and then decreased to very low levels by 1990. Spot-clearing drastically reduced bracken-fern cover for only a few months; by 1981 there was twice as much cover as there was initially. Increases by 1983 still left bracken-fern dominance on spot-cleared areas substantially below that on unprepared sites, but the status reversed after 1985. Aerial spraying reduced bracken-fern to low levels followed by a gradual increase the rest of the decade. Broadcast burning also temporarily reduced bracken-fern but stimulated its frequency and cover far beyond initial levels for most of the decade. Although sharply in decline as a dominant by the 10th year (except in sprayed areas), frequency and cover of bracken-fern still was substantial in four of the six site treatments.

Height growth of bracken-fern differed on unprepared and prepared sites (table 67). On unprepared sites, average height increased gradually to more than double the 1980 average and then declined slightly toward the end of the decade. In contrast, any site preparation caused an initial reduction in average height, followed by a gradual increase to maximum average height at the end of the decade. In three treatments, the highest average was greater than the highest average for unprepared sites. Bracken-fern grows very tall in coastal areas; maximum individual heights of 250 to 300 centimeters were measured.

Table 67—Frequency, cover, and height of *Pteridium aquilinum* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980	9.0	3.0	2.3	0.6	4.8	1.1	5.4	0.8	4.2	0.8	5.8	1.0
1980a	9.0	3.0	2.0	.1	4.8	1.1			.6	.1	.6	.1
1981	9.6	5.1	4.0	1.1	1.9	.2	9.4	1.5	7.3	2.0	10.2	2.2
1982	12.5	6.1	7.3	2.1	4.2	.8	18.1	5.8	10.2	4.4	20.6	5.4
1983	9.6	4.9	7.3	2.8	4.4	.8	24.4	10.0	12.3	5.6	22.9	7.9
1985	9.2	2.8	9.4	2.7	6.0	1.1	31.7	11.7	15.6	5.8	27.1	9.7
1987	3.8	.6	8.3	2.6	8.8	1.9	26.9	7.2	14.0	4.2	29.6	7.8
1990	1.5	.3	3.1	1.0	4.2	2.0	6.3	2.3	1.0	.2	4.2	1.4
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980	63	20-91	58	23-90	58	12-102	56	8-134	70	14-122	75	8-156
1980a	63	20-91	35	17-73	58	12-102			51	47-59	86	71-105
1981	97	29-146	55	21-115	41	28-52	47	20-84	57	13-108	52	17-127
1982	129	17-240	77	22-134	47	10-80	67	15-177	80	45-134	72	23-189
1983	126	41-212	95	24-180	55	6-117	73	18-131	88	20-140	81	20-140
1985	144	60-240	109	33-205	73	30-180	98	20-190	115	38-190	94	32-220
1987	106	22-220	125	25-250	73	31-144	113	25-274	136	40-235	115	30-300
1990	120	93-150	150	40-222	107	40-210	129	25-265	152	120-176	152	102-228

Rhamnus purshiana, found on a single spray-and-burn transect in 1980, apparently was eliminated by site preparation, but a scattering of cascara buckthorn plants invaded all treatments in the latter part of the decade (table 68). Such colonization by a heavy-seeded species was unexpected. Heights of 300 to 520 centimeters attained by the taller cascara trees will help keep them competitive with the Douglas-firs and alders for an interim period.

Table 68—Frequency, cover, and height of *Rhamnus purshiana* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980											0.2	+[a]
1980a											.2	0.1
1981												
1982												
1983					0.2	+	0.4	0.1				
1985			0.2	+			.4	+	.2	+	.2	+
1987			.2	+	.4	+	.4	.1	.6	0.2	.2	+
1990	0.8	0.3	.4	0.1	.2	+	.8	.3	.6	.3	.2	+
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980											41	41
1980a											130	130
1981												
1982												
1983					48	48	163	163				
1985			145	145			195	170-220	206	206	35	35
1987			143	143	160	160	217	163-270	278	175-360		
1990	395	300-480	330	310-350	320	320	391	93-520	295	231-400	255	255

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Ribes bracteosum was present in two site treatments in 1980 and by 1983 was represented by scattered individuals in all site treatments (table 69). The role of stink currant as an incidental dominant in all treatments spanned only 3 years, however. This intermediate height shrub, up to 240 centimeters, gradually lost its sparse dominance to competitors.

Ribes sangineum was not found on any transect at the start of the study; it later appeared infrequently and more in burned than unburned areas:

Site preparation	Year	Frequency	Cover	Average height	Range
		– – – Percent – – –		*– – – Centimeters – – –*	
None	1982	0.2	+	101	101
Spot-clear	1987	.2	+	143	143
Burn	1985	.6	+	25	15-35
	1987	.4	+	72	53-90
Slash and burn	1982	.2	.1	57	57
Spray and burn	1985	.8	+	31	15-67

Table 69—Frequency, cover, and height of *Ribes bracteosum* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
					Percent							
1980			1.9	0.7	1.7	0.4						
1980a					1.7	.4	0.2	0.1				
1981	0.2	+[a]	.2	.1			.4	.2				
1982	.4	+	.8	.2	.4	.1	.8	.1			0.2	+
1983	.2	+	.4	.1	.8	.1	.6	.4	0.4	+	.2	+
1985	.2	+	.2	+	1.3	.3	.2	.1	.2	+	.4	0.1
1987			.4	+	.4	.1						
1990			.2	.1	.2	+					.2	.2
					Height (centimeters)							
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980			70	26-131	59	25-107						
1980a					59	25-107	85	85				
1981	59	59	111	111			110	92-128				
1982	82	74-89	70	52-87	58	30-86	48	7-158			26	26
1983	70	70	85	80-90	56	23-89	207	170-240			30	30
1985	135	135			85	30-123	220	220	60	60	65	33-96
1987			145	100-190	123	96-150						
1990			130	130	110	110					195	195

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Red flowering currant is often found interlaced with other species, so its incidental occurrence among the dominant vegetation for a limited time is not unexpected.

Rosa gymnocarpa, initially present on three transects in two treatments, do not prevail through site preparation. Scattered individuals later appeared after spraying, burning, or slashing and burning (table 70). Little wood rose was an incidental dominant only from 1981 to 1987. In 1987, height of this species ranged from 50 to 120 centimeters.

Rubus laciniatus, a nonnative vine, was found occasionally in a dominant position:

Site preparation	Year	Frequency	Cover	Average height	Range
		--- *Percent* ---		--- *Centimeters* ---	
None	1982	0.2	+	40	40
	1985	.2	+		
Spot-clear	1987	.2	+	140	140
Burn	1983	.2	.1	58	58
Slash and burn	1985	.2	+	7	7
	1990	.2	+	150	150
Spray and burn	1983	.2	+		

Table 70—Frequency, cover, and height of *Rosa gymnocarpa* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980			0.2	+[a]							0.4	0.1
1980a												
1981					0.2	+	0.2	+	0.4	+		
1982			.2	+	.2	+	.2	+	.4	.1		
1983					.4	.1	.2	+	.6	.1		
1985					.4	.1	.2	+	.6	.1		
1987					.2	+	.2	+	.2	+		
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980			48	48							77	64-90
1980a												
1981					58	58	9	9	13	12-13		
1982			24	24	106	106	36	36	25	23-27		
1983					79	54-103	26	26	31	14-41		
1985					76	62-90	41	41	45	40-50		
1987					65	65	50	50	122	122		

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Because the height of evergreen blackberry depends on what it climbs, nonconsistent occurrence as a dominant is a natural consequence. It was found in most site treatments but did not show aggressive growth in any.

Rubus leucodermis, not dominant on any transects in 1980 or 1981, became and remained among the dominant cover in all treatments from 1982 to 1987 (table 71). Both the frequency and cover of black raspberry were somewhat erratic from year to year within and among treatments, but its average height increased in all treatments, ranging from 71 to 153 centimeters in 1987. It reached higher frequencies and cover amounts in sprayed and unprepared areas than elsewhere. Maximum heights exceeded 200 centimeters in some years and treatments.

Rubus parviflorus was a dominant species at the start of the study, increased until 1985, and then declined; but in 1990, it still was a common dominant in every site-preparation treatment (table 72). Site preparation reduced the initial amounts of thimbleberry present except for spot-clearing, where an immediate gain occurred. Frequency and cover of thimbleberry eventually reached notably higher levels in all site-preparation treatments than for no site preparation, but those areas also had higher amounts initially.

Table 71—Frequency, cover, and height of *Rubus leucodermis* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1982	2.3	0.2	2.1	0.2	0.4	+[a]	1.5	0.1	0.4	0.1	0.8	+
1983	3.5	.5	1.3	.2	2.1	.2	.8	.1	.8	+	.4	+
1985	5.8	1.0	1.3	.1	5.4	.7	1.5	.2	.6	+	2.7	0.3
1987	3.8	1.0	1.0	.2	1.9	.3	1.5	.1	1.0	.1	1.7	.2
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1982	69	22-102	79	33-163	21	21	26	14-33	53	32-74	23	16-27
1983	88	50-148	112	50-163	43	18-60	45	20-60	34	30-37	29	29
1985	117	38-200	129	20-230	91	20-165	56	20-100	63	40-90	75	10-184
1987	130	60-170	153	120-170	142	80-210	71	24-118	121	60-150	130	70-200

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Table 72—Frequency, cover, and height of *Rubus parviflorus* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980	0.2	+[a]	3.8	0.7	7.3	1.5	3.8	0.8	1.9	0.6	6.7	2.4
1980a	.2	+	6.0	1.0	7.3	1.5	.4	.1	.2	+	3.1	1.1
1981	2.5	0.2	9.2	1.8	1.9	.1	3.1	.3	2.9	.3	4.0	1.4
1982	7.9	.8	14.8	3.0	6.9	.4	18.8	1.6	16.5	1.7	13.5	2.2
1983	5.8	1.4	14.4	4.0	10.6	1.0	21.9	2.5	19.0	3.0	18.5	3.2
1985	10.0	2.4	16.0	5.3	20.6	3.7	22.9	4.0	20.0	4.3	24.0	5.6
1987	8.5	2.4	16.9	6.3	21.7	5.1	16.0	3.1	13.3	2.8	19.0	5.8
1990	2.7	1.0	10.0	5.2	6.7	2.9	1.0	.3	1.5	.6	3.3	1.7
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980	20	20	51	10-128	58	8-135	43	6-103	46	14-64	58	15-146
1980a	20	20	41	5-115	58	8-135	62	42-82	25	25	65	14-148
1981	25	12-45	53	12-118	20	7-37	25	7-45	25	5-48	70	14-168
1982	56	8-170	71	6-200	21	6-59	24	5-54	30	6-98	42	7-208
1983	81	14-230	86	20-190	33	10-110	35	3-82	53	7-152	54	7-180
1985	133	20-280	127	13-300	78	11-205	68	15-320	80	15-240	86	18-360
1987	184	28-300	191	26-300	140	13-260	92	23-245	125	28-280	141	40-270
1990	231	130-350	274	68-460	227	80-340	213	120-360	215	78-360	230	104-345

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Average height of thimbleberry ranged from 20 to 58 centimeters at the start of the study and, after site preparation, increased fourfold or fivefold by the end of the decade (213 to 274 cm). Thimbleberry on unprepared areas was initially much shorter and increased elevenfold in average height. Average height was not set back as much by spot-clearing as by the other site-preparation treatments. Maximum heights for thimbleberry ranged from 340 to 460 centimeters. From its height and cover responses to spot-clearing, one might suspect thimbleberry was able to recover faster than competitors and benefit from a release effect.

Rubus procerus, another nonnative vine, did not appear as an incidental dominant until 1987:

Site preparation	Year	Frequency	Cover	Average height	Range
		--- *Percent* ---		--- *Centimeters* ---	
Spot-clear	1987	0.2	+	225	225
Spray	1990	.2	+	120	120
Burn	1987	.4	+	81	62-100
Slash and burn	1987	.2	+	215	215
Spray and burn	1987	3.5	0.8	189	95-320
	1990	2.1	1.1	354	190-480

As indicated by the recorded heights, Himalayan blackberry can extend far above the ground if the species it is climbing or its own successive dead stalks are tall.

Rubus spectabilis was the predominant species present in all treatments at the start of the study and remained a prominent dominant throughout the decade. Frequency, cover, and average height of salmonberry clearly were influenced by site preparation (table 73). On unprepared sites, salmonberry comprised about four-tenths of the total cover initially, increased to nearly half of a much higher total by 1985, and then declined to comprise about one-third of the dominant cover by 1990. After a temporary reduction to 6.6 percent, the trend of salmonberry cover in spot-cleared areas was similar to that in unprepared areas. Cover was reduced to 1 percent or less by the other four treatments, and the highest recovery was less than 25 percent. Spraying with glyphosate kept salmonberry cover to 8 percent or less. In all treatments, frequency and cover of salmonberry peaked by 1985.

Salmonberry attained an average height of 242 centimeters by 1990 on unprepared sites, nearly as tall after spot-clearing, and somewhat less in the other four treatments. As late as 1987, average height was less in areas sprayed with glyphosate than elsewhere. Even though set back by site preparation, average height of salmonberry increased nearly threefold over the decade. Salmonberry has great height growth potential; maximum heights of 500 centimeters or more are not uncommon.

Table 73—Frequency, cover, and height of *Rubus spectabilis* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980	58.3	24.6	68.1	31.2	56.9	21.1	47.3	18.3	60.0	20.3	56.3	18.8
1980a	58.3	24.6	37.5	6.6	56.9	21.1	4.6	1.0	4.4	.9	2.7	.7
1981	65.0	34.4	72.1	28.9	5.0	.6	25.8	5.8	35.6	6.2	26.0	5.1
1982	71.7	39.8	80.0	45.4	15.2	1.6	37.9	10.6	59.0	15.0	42.3	11.0
1983	71.9	42.7	81.0	47.1	21.9	3.0	40.4	13.3	63.8	20.6	51.3	16.0
1985	77.3	46.3	83.3	51.5	40.8	8.1	48.8	16.2	65.2	24.0	52.3	18.2
1987	68.8	41.2	74.0	38.6	34.0	7.3	35.4	12.6	45.8	14.9	35.0	9.6
1990	43.5	31.0	42.5	25.9	9.8	4.1	15.0	8.1	10.8	6.9	6.5	2.6
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980	77	5-340	83	8-450	70	10-320	70	11-261	72	8-320	76	9-378
1980a	77	5-340	41	5-156	70	10-320	72	9-146	62	12-109	72	15-250
1981	104	9-320	63	9-188	40	6-117	53	5-216	39	6-130	43	3-143
1982	126	11-320	105	13-260	37	9-126	64	10-270	61	8-178	71	6-177
1983	130	21-325	111	17-300	48	10-152	77	13-250	73	7-240	84	6-184
1985	151	20-320	150	22-350	80	19-231	99	10-270	105	20-258	103	21-270
1987	178	26-350	174	15-400	118	10-250	125	12-480	128	23-270	127	15-280
1990	242	32-430	230	35-560	195	20-450	192	15-470	226	73-400	194	46-540

Rubus ursinus, the most common native vine, was present initially in relatively low frequencies and cover in every site treatment except spot-clearing (table 74). Broadcast burning drastically reduced trailing blackberry cover, but it was not adversely affected by spot-clearing, glyphosate spraying, or no site preparation. As with several other species, trailing blackberry dominance peaked in 1985 (except in the spray-and-burn treatment) and then declined as taller-growing species took over. The cover level attained was highest in spray treatments and lowest in spot-clear and no-site-preparation treatments.

When growing independently, trailing blackberry is a low-growing vine whose leaves may extend 10 to 20 centimeters above the soil surface. The average and maximum heights given in table 74 reflect the height of objects and species over which trailing blackberry was growing—up to 250 centimeters.

***Sambucus* spp.** were present in every treatment initially and also a decade later (table 75). Elder apparently was little affected by spot-clearing as there was only a temporary decrease in that treatment and then an increase in frequency and cover after spot-clearing and on unprepared areas until 1982, followed by slow decline. Elder was not present immediately after burning, but was present again in mid-1981, and also present at low levels following spraying. In these four treatments, elder dominance peaked in 1982 or later and was substantially less than on areas that had been spot-cleared or not site prepared.

Table 74—Frequency, cover, and height of *Rubus ursinus* by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980	1.9	0.2			7.1	1.3	3.3	0.8	3.5	0.7	10.6	2.7
1980a	1.9	.2	0.2	+[a]	7.1	1.3	.6	+	.2	+	.2	+
1981	2.7	.2	1.3	0.1	7.1	1.3	2.9	.4	1.7	.2	5.8	.6
1982	5.8	.5	4.2	.6	17.7	3.6	8.5	1.0	6.5	1.1	29.0	5.0
1983	4.6	.6	4.6	.9	20.2	4.1	9.0	1.2	6.3	.9	20.8	3.2
1985	8.3	1.0	7.9	.9	32.1	5.7	13.1	1.6	10.6	1.7	25.4	3.3
1987	5.2	.4	6.7	.8	24.6	3.5	9.6	.9	5.4	.7	16.3	1.9
1990	3.8	.6	2.9	.4	4.6	.8	3.3	.7	2.9	1.4	6.5	1.1
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980	22	10-37			22	12-42	30	11-65	23	6-44	30	6-84
1980a	22	10-37	14	14	22	12-42	18	12-30	21	21	13	13
1981	33	12-59	23	8-58	20	5-60	27	8-126	22	12-39	12	3-31
1982	42	12-122	27	14-60	31	7-95	24	7-96	25	7-68	24	8-89
1983	41	6-140	39	10-97	28	5-90	21	3-60	21	5-47	23	5-84
1985	39	10-170	29	5-88	23	5-80	24	7-65	46	7-210	32	7-140
1987	43	5-125	43	10-112	47	6-125	34	8-100	53	8-150	45	9-128
1990	78	7-174	87	14-250	65	20-135	50	10-100	118	78-170	89	10-195

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Table 75—Frequency, cover, and height of *Sambucus* spp. by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980	6.5	1.4	6.9	1.4	2.3	0.4	2.1	0.4	2.9	0.5	2.9	0.7
1980a	6.5	1.4	6.3	.7	2.3	.4						
1981	10.2	2.6	9.8	2.9	.8	.1	2.1	.2	1.3	.2	.4	.1
1982	10.4	3.5	14.6	4.5	3.3	.4	7.1	.7	5.6	.6	4.8	.5
1983	9.4	3.1	9.8	4.1	4.2	.6	6.3	1.1	5.2	.8	4.6	.7
1985	5.6	2.1	6.3	2.9	3.3	.8	2.5	.5	2.7	.9	1.5	.5
1987	5.0	2.4	7.3	2.7	2.5	.9	1.9	.4	2.1	.6	3.1	.9
1990	4.8	2.8	4.6	2.3	1.3	.6	.6	.3	.8	.4	2.3	1.1
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980	118	19-320	96	16-500	68	18-132	72	38-169	71	22-148	79	25-157
1980a	118	19-320	53	10-300	68	18-132						
1981	129	19-350	109	15-300	33	19-55	48	6-160	110	14-195	142	104-180
1982	187	19-600	136	10-300	56	16-130	48	9-180	69	11-198	54	6-255
1983	183	18-450	176	65-300	73	23-188	68	20-180	96	13-240	79	23-240
1985	259	95-700	236	120-400	146	20-260	137	31-400	175	60-300	164	80-240
1987	312	110-500	246	110-460	214	72-340	210	60-410	219	128-360	220	110-340
1990	387	180-500	358	210-480	372	240-450	423	330-480	340	280-420	345	220-500

Although not as heavily represented in broadcast-burned or sprayed areas, average heights reached by the end of the decade were similar, ranging from 340 to 423 centimeters. In terms of height, elder gained least on unprepared areas (328 percent) and most on burned only areas (588 percent). Elder is relatively fragile, and much physical damage occurs as reflected by variability in maximum heights from one examination to another.

***Senecio* spp.**, predominantly common groundsel *(S. vulgaris)* and tansy ragwort *(S. jacobaea)*, were well represented at the start of the study (frequency 8.8 percent, cover 0.8 percent), increased rapidly in all treatments to peak in 1981 (frequency 56.2 percent, cover 16.5 percent), and diminished quickly after 1983 (table 76). Groundsel abundance and cover in all treatments was markedly lower in 1982 than in 1981 and 1983. The frequency and cover of groundsels appears directly proportional to the amount of site disturbance—least with no site preparation, somewhat more with spot-clearing, and highest after spraying or broadcast burning (fig. 28). Glyphosate spraying was not followed by a temporary reduction of groundsels in 1981.

Table 76—Frequency, cover, and height of *Senecio* spp. by site preparation and year

	Site preparation											
	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
Year	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980	11.3	0.9	9.6	0.9	13.5	1.4	4.6	0.5	10.4	0.7	3.1	0.3
1980a	11.3	.9	21.0	3.3	13.5	1.4	.8	.1	3.1	.9	.2	+[a]
1981	29.0	4.2	44.2	7.4	67.3	14.9	80.6	33.1	70.8	25.3	45.0	14.0
1982	9.6	1.0	9.4	1.1	43.3	8.2	22.3	2.1	16.9	1.7	20.2	2.0
1983	15.2	3.0	21.0	4.1	62.7	18.5	49.2	14.7	51.0	15.2	47.7	11.4
1985	.4	+	2.1	.2	5.8	.6	2.5	.3	4.2	.6	5.4	.5
1987	.8	.1	5.0	.7	5.2	.8	4.2	.7	6.9	1.2	2.5	.3
1990	.4	+	1.0	.2	1.3	.4	1.0	.2	1.7	.3	.2	+
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980	41	8-95	58	9-150	54	6-127	24	2-83	16	2-90	24	5-65
1980a	41	8-95	58	5-146	54	6-127	39	11-73	86	34-181	80	80
1981	73	12-155	62	10-164	61	5-226	105	13-168	99	9-211	102	17-226
1982	69	13-130	64	16-159	61	6-307	69	6-141	62	7-144	79	8-134
1983	131	22-220	133	10-210	112	17-222	112	22-193	111	18-200	111	14-200
1985	40	40	86	5-180	100	20-185	83	12-130	66	10-204	75	22-152
1987	114	16-170	143	28-230	147	33-240	131	32-220	132	26-179	146	70-210
1990	18	18	108	54-180	102	45-160	132	60-204	118	30-175	90	90

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

July 1980

September 1980

July 1981

September 1982

June 1987

Figure 28—Groundsels were early invaders in all treatments, occurring most abundantly on disturbed areas. Note the changes in herbaceous cover on the burned area (L) and glyphosate-sprayed area (R) at Camp 76 from 1980 before site preparation to 1987.

The heights of groundsels show less pattern or trend than most other species. Average heights among treatments differed substantially at the start of the study, with those on areas to be broadcast burned averaging less than half those on unburned areas (21 vs. 51 cm). The next year, average heights for groundsels on burned areas were much greater than those on unburned areas, 102 vs. 65 centimeters; but in 1982, they were almost even, 70 vs. 65 centimeters. Then in 1983, groundsels on unburned areas were again taller than those on burned areas, 125 vs. 111 centimeters. Also, average heights differed greatly from year to year within the same treatment. Averages tended to be higher from 1983 on than they were in earlier years. The range of heights on which the averages are based is also very wide.

Tsuga heterophylla seedlings were first found in dominant position in 1985, and their numbers increased slightly by 1990:

Site preparation	Year	Frequency	Cover	Average height	Range
		--- *Percent* ---		--- *Centimeters* ---	
Spot-clear	1985	0.2	+	60	60
	1990	.4	0.1	350	350
Burn	1990	.2	.1	460	460
Slash and burn	1985	.4	+		
	1987	.2	.1	213	213
	1990	.4	.2	410	410
Spray and burn	1990	.2	+		

These naturally established western hemlocks were making good height growth relative to the planted Douglas-firs.

Vaccinium ovatum was an occasional dominant in all treatments at the start of the study and about maintained its status on unprepared sites throughout the decade (table 77). Broadcast burning completely eliminated evergreen huckleberry from dominance until 1985, and it was an infrequent dominant thereafter on burned areas. Dominance of evergreen huckleberry was affected by glyphosate spraying and spot-clearing, but after temporary setbacks, it increased slightly in both treatments.

In the decade, average height of evergreen huckleberry increased 553 percent on unprepared sites. This gain was greater than height gains in other treatments except for the rapid growth of a single individual in the burn treatment.

Vaccinium parvifolium was also an occasional dominant in all treatments at the start of the study and gained in frequency and cover on unprepared areas through most of the decade (table 78). Broadcast burning nearly eliminated dominance of red huckleberry for several years; it slowly recovered in frequency to near preburn levels but not in percentage of cover. Frequency of red huckleberry was little affected by glyphosate spraying, but its cover was reduced. After a temporary setback, red huckleberry in spot-cleared areas about matched response in unprepared areas.

Table 77—Frequency, cover, and height of *Vaccinium ovatum* by site preparation and year

Year	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980	9.6	4.2	12.5	5.0	6.9	2.0	21.0	9.9	13.3	6.2	13.1	4.6
1980a	9.6	4.2	1.3	.2	6.9	2.0					.2	.1
1980	0.8	0.1	0.6	0.1[a]	2.1	0.4	0.6	0.1	1.0	0.2	0.8	0.2
1980a	.8	.1	.2	+	2.1	.4						
1981	.4	.1	.4	.1	2.1	.4						
1982	.2	+	.8	.1	1.7	.3						
1983	.4	.2	1.0	.1	1.5	.5					.2	+
1985	.4	.2	1.0	.3	2.5	.5	.2	+	.4	.1	.4	+
1987	.4	.2	1.7	.4	3.1	.7	.2	+	.2	+	.2	+
1990	.6	.1	1.0	.3	2.1	.4	.2	+			.2	.1
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980	45	24-78	82	40-105	67	20-288	19	13-31	60	11-113	74	14-151
1980a	45	24-78	15	15	67	20-288						
1981	62	17-107	33	24-42	76	22-300						
1982	157	157	95	52-146	103	43-283						
1983	121	81-160	120	94-173	95	20-300					96	96
1985	175	155-195	111	43-173	87	20-225	42	42	95	90-100	55	22-87
1987	193	186-200	153	105-220	112	30-180	90	90	110	110	110	110
1990	249	206-280	160	92-217	141	22-320	200	200			100	100

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Table 78—Frequency, cover, and height of *Vaccinium parvifolium* by site preparation and year

Year	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn	
	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover
	Percent											
1980	1.0	0.1	1.5	0.2[a]	1.7	0.6	2.5	1.0	2.1	0.4	0.8	0.1
1980a	1.0	.1	.4	+	1.7	.6	.2	.1				
1981	1.7	.2	.2	+	1.7	.3	.4	+				
1982	1.7	.3	.2	+	1.5	.3	1.0	.1	.4	.1		
1983	1.5	.3	1.7	.1	1.9	.4	2.1	.1	1.5	.2		
1985	1.3	.4	1.3	.2	3.1	.5	3.3	.4	.6	.1	.4	+
1987	1.9	.5	1.5	.4	3.5	.5	2.9	.4	.6	.1	.2	+
1990	.8	.3	1.5	.4	.8	.3	.4	.1	.2	+		
	Height (centimeters)											
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
1980	39	16-92	89	17-185	159	32-315	131	17-340	142	26-320	101	34-195
1980a	39	16-92	26	24-27	159	32-315	55	55				
1981	78	9-240	25	25	118	14-400	24	12-35				
1982	81	20-144	68	68	128	33-270	40	22-65	70	39-100		
1983	111	18-151	78	31-180	82	21-270	53	16-106	60	31-100		
1985	162	51-250	134	48-230	101	12-280	80	35-180	104	65-126	60	60
1987	132	52-260	160	32-260	99	13-320	121	25-220	148	103-180	59	59
1990	199	40-300	249	190-320	148	36-240	195	90-300	230	230		

[a] Frequency or cover values less than 0.05 percent are indicated by a plus symbol.

Average height of red huckleberry was very variable initially, being lowest (39 cm) on unprepared sites and highest (159 cm) on areas to be aerially sprayed. Heights seem to have been reduced by spraying and afterwards probably held in check by browsing so that by the end of the decade, average heights were still lower on sprayed areas than initially. After the initial setback, there was gain in average height by 1990 in the burn and slash-and-burn treatments but not in the spray-and-burn treatment. On unprepared areas, average height of red huckleberry increased about fivefold in a decade; in spot-cleared areas, it increased almost double as much, if based on initial height after cutting.

Discussion and Recommendations

The site preparation needed to achieve desired reforestation goals is a key decision silviculturists must make on every area to be reforested. It is not a simple decision, for the desired result depends not only on site preparation but also on many other factors—choice of species; size of planting stock; target stocking density; postharvest amounts and distribution of mineral soil, slash, litter, and residual vegetation; likely hindrances from animals and competing vegetation; and site-related constraints as well as those of an economic, social, or legal nature.

This study represents a singular experimental attempt to make side-by-side comparisons on an operational scale of site-preparation methods being used or advocated in coastal forests in 1980, to determine preparation effects on vegetation as well as on tree growth, and to follow stand and vegetation development long enough to learn the durability of initial differences. Tree and vegetation development are rapid on the highly productive coastal forest lands. At 10 years, the better-stocked stands are closing, brush and herbaceous vegetation are being shaded out, and the kinds of stands and vegetation mix produced by each site preparation are clearly evident (see cover). Animal damage and vegetative competition considerations bearing on stand establishment are now secondary to such factors as tree-to-tree competition, overtopping by hardwoods, and biotic and mechanical damage sustained by young forests.

Results of this study provide new insights on site preparation, the development of young coastal stands, the early dynamics of vegetation succession, and the role of animals, particularly mountain beaver. These topics are discussed in the sections that follow.

Utility of Site Preparation

Under the reforestation conditions present in study areas, four of the five site-preparation methods significantly enhanced the survival and growth of the 2-0 Douglas-fir stock planted. Manually clearing spots had some minor beneficial effects on survival, but it did not materially enhance stand development as the other four site-preparation methods did, and it was not cost effective. Furthermore, the mediocre results of spot-clearing probably represent maximum effect in these test conditions. If spot-clearing had been applied exactly as specified to 4-foot-radius spots instead of as extensively as done by several contractors, the beneficial effects of this one-time spot-clearing probably would have been even less.

Results also show that no site preparation or seedling protection was needed under the test conditions to establish a substantial number of trees. On the average, 47 percent of unprotected trees survived with no site preparation and achieved a 10-year average height of 569 centimeters, 78 percent as tall as unprotected trees in the broadcast burn treatment (725 cm). The difference in stem volume at 10 years was much greater—3.7 times as much in the broadcast-burn treatment. If over 400 trees per acre were planted (about 10- by 10-ft spacing), 47 percent survival would provide about 200 trees per acre at age 10—enough to fully stock an area if survivors were reasonably well distributed. Uneven distribution and large openings were particularly obvious in the no-site-preparation and spot-cleared areas at LBJ.

Under the test conditions, slashing or spraying of residual vegetation to improve the subsequent broadcast burn did not prove effective. Tree survival and growth were good after burning without any pretreatment, and cost and operational complexity were less for equal or better results. Some residual vegetation remained unburned in all broadcast burned areas, averaging 2.9-, 3.7-, and 5.2-percent total cover (2.2-, 1.2-, and 2.1-percent woody cover) in burn, slash-and-burn, and spray-and-burn treatments, respectively (table 29). The figures indicate that in this test, preburn slashing or spraying did not help produce a cleaner burn. The impetus given to stand establishment by burning was illustrated by a notable example at LBJ—slash was not sufficient to fuel burning of a low knob located in the broadcast-burned area. Trees subsequently planted in this unburned part of the burn area failed to get through the salmonberry, just as they failed in the adjacent unprepared area.

Survival, total height, and stem caliper differences due to site preparation by burning or spraying vs. spot-clearing or no preparation developed slowly and are still widening at 10 years (figs. 11, 14, and 16). These differences are now reflected by the potential crop trees produced by each method (table 13). Thus, the differences caused by site preparation are certain to remain evident for many years, especially the visual contrasts between fast-growing, well-stocked stands and more open stands with patches of entrenched salmonberry.

Timing of treatments, relative to each other and the growing season, is a dominant factor in the interpretation and application of site-preparation results. In this study, residual and invading vegetation (and animals) had up to a full year to develop on unprepared areas before trees were planted. Burning in summer 1980 drastically set back the developing vegetation, spraying in autumn gradually reduced the woody component during the 1981 season, and spot-clearing in spring 1981 temporarily reduced both woody and herbaceous components. If vegetation on unprepared sites had not had as long to develop, the differences in tree survival and growth on unprepared and burned or sprayed areas might not have been as great. Because time spans for vegetation development similar to those of this study are a common reforestation reality, however, study results are representative for the conifer-alder type as well as elsewhere where salmonberry and its main associates dominate the understory.

If timing were markedly different, favorable tree response to site preparation still would be likely because residual vegetation would be reduced. The relative differences between methods might change, however. To illustrate (1) if harvesting were completed late in the growing season, yet soon enough to allow burning or spraying the same season, response of tree seedlings planted a few months later in winter or spring should not differ as much between site-prepared and unprepared areas. On the unprepared areas, residual vegetation would then not have had a 1-year head start over planted seedlings; (2) if harvesting were completed too late for spring planting but timely for spring or early summer burning, then recovering vegetation would get nearly a growing season's jump over tree seedlings on both unprepared and burned sites. The effects of an early burn, probably of low intensity, should still prove beneficial, but the gain in tree growth relative to no preparation would be less; (3) if tree seedlings could be planted before vegetation recovery starts, then spot-clearing might be more effective—either because residual vegetation is cut before it becomes vigorous or because spot-clearing can be delayed for a year or two after planting. Where vegetative competition threatens to be severe, harvesting and site preparation should be timed to provide the most competition-free conditions at planting and for several years after.

It is generally accepted that stocking and growth of young conifers can be enhanced by reducing vegetative competition (Walstad and Kuch 1987, Walstad and others 1990). Efficacy and competition studies of varying scope and duration have provided evidence that Douglas-fir seedlings benefit from reduced vegetative competition even on coastal sites, largely because of improved light or soil moisture (Allan and others 1978, Bickford and others 1965, Cole and Newton 1986, Cole and Newton 1987, Cole and others 1983, Drew 1968, Howard and Newton 1984, Newton 1964, Newton and Preest 1988, Newton and others 1987, Preest 1977, Robinson 1964, Tung and others 1986). Studies in which competition was reduced by spraying different chemicals or formulations before or soon after planting have been most common; the comparison of entirely different site-preparation methods, as in this study, have been quite uncommon.

In the few large-scale comparisons, site-preparation effects similar to those of this study have been reported. After 7 years, seedling survival in the Coastal Reforestation Systems study averaged 13 percent greater and total height 21 percent higher in the spray-and-broadcast burn treatment than without site preparation (Stein 1990). Tree responses in the spray-only and the burn-only treatments were intermediate to those in the other two treatments. Newton[3] reported that 12 years after planting extra large Douglas-firs at Hamer Lake near Nashville, Oregon, total height averaged tallest in scarified areas, followed by those in areas subjected to spray-and-crush, spray-only, and brown-and-burn treatments. In a retrospective study of genetic plantations in western Oregon, Minore and Weatherly (1990) determined that survival and growth of Douglas-fir were higher after broadcast burning slash on cable- or tractor-yarded sites than if slash were piled and burned on site, or offsite, even after remedial tilling. A single manual cutting proved ineffective for control of thimbleberry in a comparison of manual and chemical control methods in British Columbia (LePage and others 1991). These major studies show that site-preparation efforts can yield large benefits and that not all methods of site preparation are equally effective.

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[3] Personal communication. 1992. Michael Newton, professor of forest ecology, Oregon State University, College of Forestry, Corvallis, Oregon 97331.

Protection of Seedlings

Protection provided by plastic mesh tubing accounted for decade-long survival in this study of one more tree in five—survival of protected trees 78.4 percent, unprotected trees 65.2 percent. In addition, protected survivors averaged 6 percent taller and 9 percent larger in stem caliper and d.b.h. The average yield was 49 percent greater for protected seedlings than for unprotected seedlings (fig. 1, table 17) but required greater expenditures. Protection substantially improved seedling performance in every site-preparation treatment. Thus, seedling protection should be an important consideration regardless of the method of site preparation planned.

To some extent, seedling protectors compensated for lack of disturbance during site preparation; that is, differences in survival between unprotected and protected seedlings were greatest on unburned sites. Survival differences on unburned sites ranged from 15.0 to 24.4 percent, on burned sites from 5.1 to 9.9 percent (table 16). No such significant interaction between site preparation and protection was shown for total height, stem caliper, or d.b.h. (table 8).

Prevention of clipping mortality, primarily from mountain beavers, was the main function served by plastic mesh tubes. They also prevented severe browsing by deer, elk, rabbits, and hares when seedlings were small, which may explain the greater total height, stem caliper, and d.b.h. attained by protected seedlings. Early gains due to browse protection seem indicated by a second-year difference in total height of 30 percent between protected and unprotected trees (table 82). Although the tall, narrow tubes interfered with development of lower side branches, sometimes impeded terminal emergence (fig. 29), and caused some stem deformities and occasional toppling, there still was an important net gain in growth. The main protective effect was in the first 2 years (fig. 15), just when seedlings most need a boost to get above competing vegetation and browsing height.

In the Coastal Reforestation Systems study, where plastic mesh tubes were applied to rows of seedlings instead of every other tree, seventh-year survival was 84 percent for protected trees and 53 percent for unprotected trees. Protected trees also averaged 8 percent taller than unprotected trees (Stein 1990).

Protecting seedlings is obviously important in areas where high incidence of stem clipping by mountain beaver and other animals is likely. One bite can sever the stem near ground line; the seedling rarely survives, let alone recovers to be competitive. Infrequently, side branches and the terminal shoot are cut from 4- to 6-foot saplings; and subsequent new growth is cut repeatedly, keeping the live stub as a feeding station. Mountain beaver readily can, but usually do not, cut through or burrow under the tubes which have been used to protect many plantings. Other quantitative evaluations of tubing effectiveness are very sparse.

Putting a barrier around the seedling is not the only protection option; there are two others—changing the habitat or removing the damaging animals. Different site-preparation methods change habitat of offending animals to different degrees (Owston and others 1992). Judging from the differences protection produced, spot-clearing or spraying did not change habitat enough to inhibit or eliminate damaging animals any more than on unprepared sites (24.4, 15.9 vs. 15.0 percent damage, respectively); burning did. Burning increased animal exposure and lowered the vegetative food supply for mountain beaver and other rodents. By the time seedlings were planted about 6 months later, the residual animal population probably was lower, and immediate incentives for inward migration were low. No direct control

Figure 29—Long, narrow tubes impede low side branch development and sometimes also terminal emergence but not the vigorous first-year shoot growth of this seedling (Farmer, November 1981).

of mountain beaver was allowed on the study sites, but direct control by trapping is often favored rather than tubing. The method used may be one of choice and circumstances. Where mountain beaver are a threat, the need for some protective measure is clearly evident.

Vegetation Development

Dominance rather than species presence was measured in this study because the species that gain dominance control the site. In the fast-growing, densely competitive coastal vegetation, the data based on dominance often reflect fairly closely the presence of the species. Most species and stems that lose dominance are crowded out. Somewhat shade-tolerant species such as sword-fern, deer-fern, lady-fern, oxalis, little wood rose, and others may continue to be present in subdominant positions if the overstory is not too dense. All stages of vigor can be seen as species no longer dominant respond to the environmental resources still available to them.

The composition, frequency, and cover of residual vegetation dominant on unprepared sites and how these parameters changed over time constituted the primary baseline data for identifying vegetation differences caused by site preparation. The vegetation present in treatment areas and how species, frequency, and cover changed from before site preparation to afterwards provided a corollary means of evaluating site-preparation effect. Both avenues of comparison were used to identify similarities and differences in vegetation development that followed site preparation.

Table 79—Key changes in vegetative cover by site treatment from 1980 to 1990

Vegetative cover	Site preparation: None	Spot-clear	Spray	Burn	Slash and burn	Spray and burn
Total (percent):						
Initial-1980	56.6	55.2	48.8	48.6	45.6	56.3
Posttreatment—	56.6	26.1	48.8	2.9	3.7	5.2
1981	81.7	67.3	50.8	60.5	61.0	59.6
1985	95.6	95.0	86.2	87.1	91.9	92.8
1990	99.7	99.5	99.2	99.7	99.8	99.9
Ratio of Woody:						
Initial-1980	.63	.74	.62	.69	.67	.59
Posttreatment—	.63	.34	.62	.76	.32	.40
1981	.58	.56	.19	.15	.15	.15
1985	.80	.83	.63	.64	.72	.67
1990	.96	.95	.94	.94	.99	.97
Salmonberry (percent):						
Initial-1980	24.6	31.2	21.1	18.3	20.3	18.8
Posttreatment—	24.6	6.6	21.1	1.0	.9	.7
1981	34.4	28.9	.6	5.8	6.2	5.1
1985	46.3	51.5	8.1	16.2	24.0	18.2
1990	31.0	25.9	4.1	8.1	6.9	2.6
Douglas-fir (percent):						
1981	.9	1.6	1.8	1.3	1.9	1.6
1985	10.2	11.9	24.6	25.9	24.3	27.0
1990	34.2	40.7	61.8	55.6	56.6	57.7
Alder (percent):						
1985	3.9	1.5	.8	3.1	7.3	3.0
1990	14.4	13.9	17.0	26.0	31.4	28.4

After removal of the overstory, about half the ground surfaces on the study areas were still covered with vegetation (table 79). Cover increased without interruption on unprepared areas while it was differentially reduced by site preparation—by burning to 5 percent or less, by spot clearing to 26 percent, and hardly any by spraying. Vegetation recovery due to invading species, resprouting, and growth of residual plants was very fast, however, exceeding the original postharvest level in every treatment by midsummer of the first season—1981. Total cover then had reached 82 percent on unprepared sites, 67 percent on spot-cleared areas, 60 percent on burned areas, and only 51 percent on sprayed areas. Cover increased more gradually after 1981, with the total on spot-cleared areas approaching that on unprepared areas by 1982, but not until 1985 or later on other areas.

The site-preparation treatments not only differentially influenced total cover for varying periods, they also differentially influenced the species mix—particularly the proportion of the cover comprised of herbaceous and woody species (table 79). Woody species initially comprised two-thirds of the residual vegetation. In mid-1981, they comprised over half the increased total cover on unprepared and spot-cleared areas, whereas in other areas, woody species then comprised less than one-fifth of the total (fig. 24). By 1985, woody cover (including Douglas-fir) was four-fifths of the total in unprepared and spot-cleared areas, about two-thirds in other treatments. The proportion of woody cover on burned or sprayed areas did not match or exceed that on spot-cleared or unprepared areas until after 1987.

Changes in total, woody, and herbaceous cover occurred after site preparation without drastic shifts in the dominant species represented. By and large, the same species comprised most of the dominant cover in unprepared areas as in site-prepared areas, but frequency and cover percentages were different. Of the eight species or groups that averaged more than 1-percent cover originally, seven were well represented (most at greater than 1 percent) throughout the decade—vine maple, salal, grasses, sword-fern, bracken-fern, thimbleberry, and salmonberry (tables 28 to 35). Other species or groups that averaged more than 1-percent cover in all treatments for 1 or more years included candy flower, fireweeds, burnweed, deervetch, foxglove, trailing blackberry, elder, pearly-everlasting, groundsels, and red alder. Bigleaf maple was the only species averaging 1-percent cover or more that was not represented in all treatments; its presence was largely on unburned areas. Douglas-fir, the species purposely introduced into the successional pattern, was the sole invader to gain commanding dominant status among 10th-year associates in all treatments.

Salmonberry, the predominant cover originally, was drastically reduced by all site-preparation treatments, especially by glyphosate spraying; but it bounced back within the same year in spot-cleared areas (fig. 24B). Posttreatment cover of salmonberry peaked in 1985 in every treatment—around 50 percent in unprepared and spot-cleared areas, under 25 percent in the other areas (table 73). By 1990, it was losing dominance in all treatments, being less than 8 percent of the cover in burned or sprayed areas, 26 and 31 percent in the spot-cleared and unprepared areas, respectively. Reductions in both density and height of salmonberry caused by burning or spraying provided the opportunity for other species, especially Douglas-fir, to expand and thrive. By 1985, Douglas-fir cover averaged 25 percent in burned or sprayed areas, less than half as much in unprepared and spot-cleared areas. In 1990, cover of Douglas-fir in spot-cleared and unprepared areas still lagged 15 percent or more behind that in other areas.

Red alder became an important fraction of the total cover between 1985 and 1990 with nearly twice as large a representation on burned areas as on unburned areas. Interestingly, for every treatment, the sum in 1990 for Douglas-fir, red alder, and salmonberry cover constitutes 80 percent or more of the total cover. Salmonberry is clearly losing dominance; and in some places, especially Camp 76, Douglas-fir also may lose dominance to red alder (fig. 25).

As an overall effect on vegetation, site preparation diminished control of the site by the existing plant community. Harvesting the overstory was the primary step in changing site occupancy. But in conifer-alder stands, a vigorous residual understory has the demonstrated capability of expanding rapidly to fully reoccupy the site. Site preparation diminished this residual vegetation, thus providing more bare soil and a longer interval in which a somewhat different mix of species could become established. Study results confirm that site preparation by burning or spraying enhances establishment of planted Douglas-fir, but it also favors establishment of red alder, a major competitor. Burning or spraying were followed by marked but temporary increases in herbaceous cover (fig. 28) which hindered tree establishment less than woody vegetation did, as well as providing more variable habitat for animals and birds.

Previous vegetation studies, made in different locations within the Coast Ranges, have provided understanding on the dynamics of early vegetation succession. The following brief statements enhance our understanding of succession by meshing past and current study results.

- Following site preparation by various means, the vegetative cover returns rapidly to pretreatment levels (Brown 1963, Isaac 1940, Isaac 1943, Malavasi 1978, Roberts 1975).
- Early plant succession involves an increase in species diversity and a large influx of invading species (Brown 1963, Isaac 1940, Isaac 1943).
- Invading species commonly found include *Senecio* spp., *Gramineae* spp., *Lotus* spp., *Cirsium* spp., *Epilobium* spp., *Pteridium aquilinum*, *Rubus ursinus*, *Erechtites* spp., *Digitalis purpurea*, and *Anaphalis margaritaceae*. (Brown 1963, Isaac 1940, Isaac 1943, Morris 1970, Roberts 1975).
- *Senecio sylvatica*, a northern European adventive, has adapted well as a short-term dominant on slash-burned clearcuts. It has low competitive ability and apparent high fertility requirements (West and Chilcote 1968).
- Herbaceous species are soon replaced by the native perennial species (Brown 1963, Isaac 1943, Malavasi 1978).
- Biomass and composition data for river-bottom red alder stands of different ages provide indications that alder may eventually be succeeded by salmonberry in the absence of suitable conifer seed source (Henderson 1970).
- Choice of site-preparation method can affect both the composition and density of woody cover and the degree of animal use (Malavasi 1978, Morris 1970).

Information on the autecology, distribution, competitive status, reproductive and growth characteristics, and response to silvicultural treatments of early successional species have been compiled by Coates and Haeussler (1986) and Haeussler and Coates (1986).

Interrelations

Every one of the 12 site-preparation combinations tested in this study might be a suitable component of reforestation strategy after clearcutting in the salmonberry type depending on the goals set by management. The minimum number of crop trees required at 3 years by the Oregon Forest Practices Act until 1991—150 well-distributed, established trees per acre (Oregon Department of Forestry 1992)—was still met at 10 years, though barely so at LBJ, where survival without site preparation or protection was 34.5 percent for trees planted at 3- by 3-meter (10- by 10-ft) spacing. Tree survival with no site preparation or protection ranged from 34.5 to 58.8 percent in the four areas; with protection, from 44.8 to 77.4 percent. If no site preparation were used, protecting the seedlings with plastic mesh tubing would provide more certainty that minimum stocking would be achieved on every area planted. Also, if seedlings were protected, fewer might need to be planted.

Clearly, site preparation, or protection, or both were required to obtain better than minimum stocking and growth, even in moist coastal conditions. This is evident from study results as well as from other studies already cited. Protection is needed where high seedling losses from clipping are likely. Reduction of competing vegetation is commonly needed so trees have enough light and moisture for rapid early growth. Four of the site-preparation treatments temporarily reduced vegetation competition enough to enhance tree survival and growth. The results obtained were not the maximum possible if competing vegetation had been kept fully in check for a longer period.

The outcomes of this study are consistent with two well-recognized reforestation principles: (1) reduce vegetative competition to improve conifer seedling survival and growth and (2) protect seedlings by some means if high levels of animal damage are likely. The study yielded quantitative survival, growth, and volume data resulting from different levels of competition reduction with and without seedling protection from animals. The results are most specific to clearcuts in the salmonberry brush type but certainly have wider applicability throughout the Coast Ranges and beyond wherever a heavy cover of competing vegetation develops rapidly and populations of foraging mammals are high. If reducing vegetative competition for a short time substantially improves seedling survival and growth in moist Coast Range conditions, one can reasonably infer the differences would be even greater for reforestation conditions where soil moisture deficits are greater and more prolonged.

Does use of bigger planting stock reduce or eliminate the need for seedling protection? Study results contribute evidence on such a suggested tradeoff. Planting stock at Farmer was taller, twice as large in diameter, and several times heavier than stock used at other sites (table 6). Survival was 11 percent higher at Farmer than the average for the other three areas for either protected or unprotected trees. But survival of protected trees at Farmer was still 13 percent higher than for unprotected trees, the same as the average survival difference between protected and unprotected trees in the other three areas. Larger stock survived better, but its protection still produced a substantial gain.

The costs developed in this study for each site-preparation method comprise only one example of many. Change the cost of spraying, of chemicals, of manual slashing, or of other components and the ranking of methods for relative cost effectiveness may differ. Biological gains due to burning or spraying and tree protection are large; their relative cost effectiveness for reforesting sites dominated by vigorous salmonberry will differ depending on individual circumstances.

Tree development in this study reflects only the effects of site preparation and protection without benefit of any followup release. Many trees planted without site preparation or in spot-cleared areas could have benefited from some timely release. So too could a more limited number in other site-preparation treatments. And a developing need for some release of Douglas-fir from red alder is evident. It is encouraging to learn that survival and growth of Douglas-fir can be enhanced by site preparation and protection; it is also important to recognize, however, that even better results are possible by including a relatively minor release effort.

Under what conditions might some release not only be desirable but critically important? When vegetation is taller than the trees, it is not easy to predict with certainty that enough trees will outgrow the competition. Trees stay alive for a time without growing or having potential as contributing components of the stand. Thus, percent survival can be a highly deceiving and tardy indicator of plantation well-being. In this study, large gains in seedling performance were fostered by two site-preparation effects on vegetation: (1) a single-season knockdown and quick, partial recovery followed by relatively small lingering differences in total cover and (2) a high ratio of herbaceous to woody cover for about the first 5 years. Thus, as a rough guide, release is critically important when young Douglas-fir plantations are overtopped by a heavy cover of predominately woody species. Need for release also may be identified by more technical measures, such as the competition index suggested by Brand (1985).

Tree survival and growth, protection effects, and the vegetative competition and composition measured in this study reflect many influences. Several influences that contributed to the results but were not measured directly need to be recognized:

- Planting was physically easier after all site-preparation treatments except spraying.
- Site preparation reduced vegetative cover, but it also produced new plants and shoots that attracted animals. Animals caused some damage to tree seedlings but also browsed succulent vegetation enough to partially check growth of competing species. The loss of dominance by vine maple and red huckleberry was probably more attributable to heavy browsing and clipping than to any other causes.
- Site preparation kept areas open longer and fostered higher and more prolonged browsing, which in turn kept the soil more bare and disturbed, especially in areas sprayed with glyphosate.

Achieving Successful Reforestation

Methods that produced fully satisfactory reforestation in the Oregon Coast Ranges were already widely practiced when this site-preparation comparison study was started. The study quantified the differences to be expected when using different methods of site preparation and provided insights on what site preparation is needed and how it can be made most effective. But site preparation is only one of the key elements contributing to reforestation success.

To consistently achieve good reforestation, and especially to maximize early plantation development, all of these elements must be given due attention and meshed into a functioning reforestation system:

- Time harvesting and planting to keep preplanting development of competing vegetation to a minimum.
- When much residual vegetation, newly developed growth, or sprouting brush is present, use appropriate site preparation.
- Whenever possible, time site preparation to minimize vegetation recovery before planting.

- Plant good quality, reasonably large stock and protect it from animal damage if significant losses are anticipated. Protection can be especially critical on small areas with minimum site preparation and when planting at wide spacing. When necessary, use of larger stock can partially compensate for less effective site preparation or lack of seedling protection (Howard and Newton 1984, Stein 1990).
- Monitor plantation development closely to identify as early as possible the need for protection from animal damage or release from competition.

Harvesting and site preparation diminish and disturb existing vegetation and, thus, free resources for use by residual and new species. Relatively slow-developing conifers have their best opportunity to establish and grow well if they are in place before the fast expansion of competing vegetation engulfs them.

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Units of Measure

Most data were collected, summarized, and reported in metric units. For reader convenience, English equivalents are given in parentheses up to the results and discussion sections where this practice seemed too repetitive and distractive. Also, certain tabular and text numbers are clearer for the primary audience if given in English units, and this has been done. Equivalents for the units of measure used are:

1 millimeter = 0.0394 inch
1 centimeter = 0.3937 inch
1 meter = 3.28 feet
1 kilometer = 0.62 mile
1 hectare = 2.471 acres
1 ton (metric) per hectare = 0.446 ton (short) per acre
1 cubic meter = 1.308 cubic yards

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Appendix

Table 80—Decade-long survival of unprotected and protected Douglas-firs in each site preparation

Time and category	None		Spot-clear		Spray		Burn		Slash and burn		Spray and burn		All	
	No.	*Percent*	*No.*	*Percent*	*No.*	*Percent*	*No.*	*Percent*	*No.*	*Percent*	*No.*	*Percent*	*No.*	*Percent*
At planting:	443	100.0A[a]	463	100.0A	454	100.0A	464	100.0A	452	100.0A	470	100.0A	2,746	100.0
Unprotccted	220	100.0	229	100.0	224	100.0	231	100.0	224	100.0	232	100.0	1,360	100.0A
Protected	223	100.0	234	100.0	230	100.0	233	100.0	228	100.0	238	100.0	1,386	100.0A
First year:	365	82.8A	410	88.6A	392	86.2A	393	85.0A	391	86.7A	434	92.3A	2,385	86.9
Unprotected	177	80.9	195	85.3	183	81.6	193	83.9	187	83.7	210	90.5	1,145	84.3B
Protected	188	84.8	215	91.9	209	90.8	200	86.0	204	89.8	224	94.1	1,240	89.6A
Second year:	324	73.7A	374	80.8A	368	80.9A	383	82.9A	373	82.7A	419	89.1A	2,241	81.7
Unprotected	150	68.8	167	73.2	165	73.7	188	81.8	173	77.5	201	86.5	1,044	76.9B
Protected	174	78.6	207	88.5	203	88.2	195	83.9	200	88.0	218	91.6	1,197	86.5A
Third year:	298	67.8Ay	350	75.6Azy	364	80.1Azy	380	82.2Azy	373	82.7Azy	410	87.2Az	2,175	79.3
Unprotected	130	59.5	149	65.2	162	72.4	186	81.0	173	77.5	197	84.9	997	73.4B
Protected	168	76.0	201	85.9	202	87.7	194	83.5	200	88.0	213	89.6	1,178	85.1A
Fourth year:	283	64.3Ay	341	73.6Azy	362	79.6Azy	375	81.2Az	372	82.5Az	403	85.7Az	2,136	77.8
Unprotected	120	54.8	142	62.2	161	71.9	184	80.1	173	77.5	192	82.8	972	71.5B
Protected	163	73.8	199	85.0	201	87.3	191	82.2	199	87.5	211	88.7	1,164	84.1A
Fifth year:	279	63.4Ay	333	71.9Azy	362	79.6Az	371	80.3Az	370	82.0Az	398	84.7Az	2,113	77.0
Unprotected	119	54.4	136	59.5	161	71.9	181	78.8	171	76.6	191	82.3	959	70.6B
Protected	160	72.5	197	84.2	201	87.3	190	81.8	199	87.5	207	87.1	1,154	83.4A
Seventh year:	271	61.6Ay	324	69.9Azy	361	79.4Az	369	79.9Az	370	82.0Az	392	83.4Az	2,087	76.0
Unprotected	116	53.0	129	56.4	160	71.5	181	78.8	171	76.6	185	79.7	942	69.3B
Protected	155	70.2	195	83.3	201	87.3	188	81.0	199	87.5	207	87.1	1,145	82.7A
Tenth year:	240	54.5Bx	294	63.5AByx	353	77.6Azy	352	76.2ABzy	350	77.6Azy	382	81.3Az	1,971	71.8
Unprotected	103	47.0	117	51.3	156	69.7	169	73.7	162	72.7	178	76.7	885	65.2B
Protected	137	62.0	177	75.7	197	85.6	183	78.8	188	82.6	204	85.8	1,086	78.4A

[a] Means followed by the same capital or lower case letter do not differ significantly by Duncan's test—capital letters denote 0.01-probability level or less; lower case letters denote 0.05-percent probablility level and are shown only if the significance rankings differ at the 2 probability levels.

Table 81—Periodic amount of mortality by study location

Periodic examination	Study location									
	Formader		LBJ		Camp 76		Farmer		Total	
	No.	*Percent*	*No.*	*Percent*	*No.*	*Percent*	*No.*	*Percent*	*No.*	*Percent*
1981	126	34.9	103	28.5	105	29.1	27	7.5	361	100.0
1982	44	30.6	39	27.1	44	30.6	17	11.8	144	100.0
1983	11	16.7	22	33.3	13	19.7	20	30.3	66	100.0
1984	9	23.1	9	23.1	9	23.1	12	30.8	39	100.0
1985	3	13.0	9	39.1	5	21.7	6	26.1	23	100.0
1987	6	23.1	7	26.9	5	19.2	8	30.8	26	100.0
1990	10	8.6	13	11.2	52	44.8	41	35.3	116	100.0
Total	209	27.0	202	26.1	233	30.1	131	16.9	775	100.0

Table 82—Periodic total height of unprotected and protected Douglas-firs in each site preparation

Time and category	Site preparation						
	None	Spot-clear	Spray	Burn	Slash and burn	Spray and burn	All
				Centimeters			
At planting:	42.5A[a]	42.5A	44.0A	43.4A	42.0A	41.4A	42.6
Unprotected	42.2	43.4	43.7	43.9	42.2	41.4	42.8A
Protected	42.7	41.7	44.4	43.0	41.9	41.3	42.5A
First year:	49.2A	49.7A	47.6A	50.5A	49.8A	48.0A	49.1
Unprotected	45.4	46.7	44.9	47.3	46.0	44.0	45.7B
Protected	53.0	52.7	50.4	53.8	53.7	51.9	52.6A
Second year:	68.8A	71.3A	65.1A	74.1A	72.8A	74.5A	71.1
Unprotected	58.4	63.6	55.9	64.0	64.3	64.5	61.8B
Protected	79.2	78.9	74.3	84.2	81.4	84.5	80.4A
Third year:	96.0Ay	103.Azy	103.1Azy	117.8Azy	117.2Azy	118.6Az	109.3
Unprotected	84.4	93.0	90.4	105.2	107.7	105.9	97.8B
Protected	107.7	113.3	115.7	130.4	126.6	131.3	120.8A
Fourth year:	134.2Ay	142.8Azy	153.6Azy	173.6Az	174.1Az	169.9Az	158.1
Unprotected	122.9	132.3	138.6	159.1	162.6	155.2	145.1B
Protected	145.6	153.3	169.0	188.2	185.5	184.6	171.0A
Fifth year:	174.2Cy	185.9BCy	211.2ABCzy	235.3ABz	244.4Az	229.5ABCz	213.4
Unprotected	162.3	177.3	195.5	218.9	232.7	215.7	200.4B
Protected	186.1	194.4	227.0	251.8	256.1	243.4	226.5A
Seventh year:	312.2Cy	324.8BCy	391.1ABz	429.5Az	438.4Az	419.4Az	385.9
Unprotected	299.6	325.1	373.4	404.0	424.3	404.8	371.9B
Protected	324.8	324.4	408.8	455.0	452.6	434.0	399.9A
Tenth year:	591.6By	582.4By	690.6ABz	756.2Az	746.6Az	712.4Az	680.0
Unprotected	568.6	584.1	664.4	725.3	729.4	690.9	660.4B
Protected	614.7	580.6	716.9	787.0	763.8	733.9	699.5A

[a] Means followed by the same capital or lower case letter do not differ significantly by Duncan's test—capital letters denote 0.01-probability level or less; lower case letters denote 0.05-percent probablility level and are shown only if the significance rankings differ at the 2 probability levels.

Table 83—Periodic stem caliper at 15 centimeters and 10th-year d.b.h. of unprotected and protected Douglas-firs in each site preparation

	Site preparation						
Time and category	None	Spot-clear	Spray	Burn	Slash and burn	Spray and burn	All
	Millimeters						
At planting:	5.1A[a]	5.3A	5.3A	5.3A	5.1A	5.1A	5.2
Unprotected	5.2	5.4	5.3	5.4	5.1	5.0	5.2A
Protected	5.1	5.2	5.4	5.3	5.0	5.1	5.2A
First year:	6.1A	6.3A	6.3A	6.6A	6.5A	6.3A	6.4
Unprotected	6.2	6.4	6.3	6.7	6.3	6.3	6.4A
Protected	6.0	6.2	6.3	6.5	6.7	6.4	6.4A
Second year:	8.2Ay	8.6Ay	9.2Azy	10.2Az	10.0Az	10.0Az	9.4
Unprotected	8.0	8.3	8.7	9.7	9.7	9.5	9.0B
Protected	8.4	8.8	9.7	10.7	10.4	10.4	9.7A
Third year:	11.7By	12.0By	14.7ABz	16.9Az	16.6Az	16.2ABz	14.7
Unprotected	11.5	11.8	13.7	16.1	16.1	15.5	14.1B
Protected	11.9	12.2	15.6	17.7	17.2	16.9	15.3A
Fourth year:	16.9B	17.1B	23.3AB	26.9A	26.2A	24.9A	22.5
Unprotected	16.9	16.9	22.4	25.9	25.8	24.4	22.1A
Protected	16.9	17.2	24.3	27.9	26.6	25.3	23.0A
Fifth year:	23.5B	23.7B	34.0A	39.3A	38.4A	36.2A	32.5
Unprotected	22.9	23.8	32.5	37.4	37.8	35.2	31.6B
Protected	24.0	23.6	35.5	41.1	39.0	37.3	33.4A
Seventh year:	47.6Bx	48.7Bx	70.4Ay	79.3Az	77.2Azy	74.8Azy	66.3
Unprotected	45.7	49.3	66.7	74.2	73.8	72.5	63.7B
Protected	49.5	48.2	74.2	84.3	80.6	77.1	69.0A
Tenth year:	111.8B	111.8B	141.4A	153.8A	148.9A	142.4A	135.0
Unprotected	106.0	110.5	132.1	144.5	142.6	138.8	129.1B
Protected	117.5	113.0	150.6	163.1	155.2	146.0	140.9A
D.b.h., 10th year:	86.5B	87.4B	105.9A	113.8A	112.8A	108.2A	102.5
Unprotected	81.4	86.1	99.7	107.9	108.0	104.9	98.0B
Protected	91.7	88.7	112.2	119.7	117.6	111.6	106.9A

[a] Means followed by the same capital or lower case letter do not differ significantly by Duncan's test—capital letters denote 0.01-probability level or less; lower case letters denote 0.05-percent probablility level and are shown only if the significance rankings differ at the 2 probability levels.

Table 84—Costs of plantation establishment for each site preparation with and without seedling protection

Activity and components	Site preparation					
	None	Spot-clear	Spray	Burn	Slash and burn	Spray and burn
	Dollars per acre					
Site preparation:						
Preparation	—	—	10	10	15	15
Slashing	—	200	—	—	100	—
Chemicals	—	—	45	—	—	77
Spraying	—	—	50	—	—	50
Broadcast burning	—	—	—	200	200	200
Admin. and inspection	—	4	10	2	4	10
Subtotal	0	204	115	212	319	352
Planting:						
Contract preparation	5	5	5	5	5	5
Stock- 400 2-0 Df	60	60	60	60	60	60
Storage	5	5	5	5	5	5
Planting	150	150	150	80	80	80
Admin. and inspection	7	10	7	4	4	4
Subtotal	227	230	227	154	154	154
Total cost, unprotected	227	434	342	366	473	506
Relative cost	1.00	1.91	1.51	1.61	2.08	2.23
Tubing:						
Contract preparation	1	1	1	1	1	1
Tubing	100	100	100	100	100	100
Installation	140	140	140	100	100	100
Admin. and inspection	3	3	3	2	2	2
Subtotal	244	244	244	203	203	203
Total cost, protected	471	678	586	569	676	709
Relative cost	1.00	1.44	1.24	1.21	1.44	1.51

Stein, William I. 1995. Ten-year development of Douglas-fir and associated vegetation after different site preparation on Coast Range clearcuts. Res. Pap. PNW-RP-473. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 115 p.

Ten-year results are presented from an operational-sized, replicated experiment in the Coast Ranges of Oregon, to determine the effects of six site preparation methods on the subsequent survival and growth of Douglas-fir and associated species. Site preparation and seedling protection with plastic mesh tubing significantly enhanced tree development. Site preparation also produced large differences in frequency and cover of associated species but only minor differences in the species represented. Dynamics of individual species or groups are brought out in text and tables showing frequency, cover, and height over the decade.

Keywords: Reforestation, Pacific Northwest, Coast Ranges, clearcutting, Douglas-fir, red alder, salmonberry, groundsels, site preparation, broadcast burning, slash and burn, spray and burn, manual spot-clearing, Tordon 101, glyphosate, planting, seedling protection, seedling survival, seedling growth, plastic mesh tubes, vegetation succession, species diversity, relative costs.

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